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BEING

FIGURES AND DESCRIPTIONS OF THE ORGANIC REMAINS PROCURED DURING  
THE PROGRESS OF THE GEOLOGICAL SURVEY OF INDIA.

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Ser. XIII. SALT-RANGE FOSSILS.

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I. PRODUCTUS-LIMESTONE FOSSILS:

iv. (fas. 3.) BRACHIOPODA.

WITH PLATES I—LVII.

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## III. Sub-Order: APHANEROPEGMATA, sive PRODUCTACEA.

Family: *PORAMBONITIDÆ*.

Up to very recent times the shells belonging to this family were but rather incompletely known, and the relations of the family to other groups of Brachiopods could only be more or less guessed at. A short time ago, however, a paper by Noetling appeared in the "Zeitschrift d. Deutsch. Geolog. Gesellschaft," which gives very explicit details as to the internal structure of these shells, so that the systematic placement of them does not any longer encounter unsurmountable difficulties. By Noetling himself the systematic position of the genus *Porambonites* has been assigned in the following manner: he demonstrates that rather close affinities exist on the one hand between this genus and *Orthisina*, and on the other hand between it and *Pentamerus*. According to Dr. Noetling's description, these affinities seem in fact well founded, and *Porambonites* appears as a strange intermediate link between the *Pentamerinae* and the *Aphaneropegmata* as a body. Nevertheless I should not like to affiliate the genus *Porambonites* so closely with the genus *Pentamerus* as to unite the two genera into one family, *Porambonitidæ*, and to separate the latter genus altogether from the *Rhynchonellidæ*, as has been done by Noetling. The chief objection to be made against such a proceeding lies in the structure of the shell of *Porambonites*, in which both valves bear a small but distinct area, and both possess a triangular open deltidial fissure. These characters approach *Porambonites* more to the *Orthis*-like shells than to the *Rhynchonellidæ*, from which latter family the genus also deviates by the constant absence of any kind of crura. On the whole, even after the very able exposition of the interior of these shells by Noetling, the genus still appears to be so peculiar that it may well be considered as forming a family by itself—a view that has been long since held by Davidson and others.

Yet another genus has been brought by Zittel into close connection with *Porambonites*; it is *Syntrielasma*, Meek, a genus which is for us of special interest as being rather largely represented in the Salt-range. It cannot be denied that the genus exhibits a certain affinity to *Porambonites*, but this affinity seems not to be closer than that existing between the latter genus and *Orthis*. But since at the same time certain peculiarities in the internal characters of *Syntrielasma* occur, by which the genus deviates widely from *Porambonites*, whilst just by these peculiarities it appears more nearly related to *Orthis*, I have preferred to place the genus in the family *Orthidæ* instead of in *Porambonitidæ*.

We thus see that by the genus *Porambonites* the *Aphaneropegmata* are linked to the *Rhynchonellidæ*, and especially to the *Pentamerinae*, rather than to any of the

*Helicopegmata*, whilst the latter on the contrary are linked on their part again to the *Rhynchonellidæ* by the family *Atrypidæ*.

If we exclude the genus *Syntrielasma* from the family *Porambonitidæ*, then the family is not represented in the Salt-range.

#### Family : *ORTHIDÆ*.

In contravention of the general rule, I must, though reluctantly, separate a family *Orthidæ* from the remainder of the *Strophomenidæ*. If we attentively examine the features by which the genus *Orthis* is characterised, there is chiefly one point deserving special attention ; this is the existence of rudimentary crura in the dorsal valve on both sides of the cardinal process—a feature which is absolutely absent in all the other genera of *Strophomenidæ*. By this feature the *Orthidæ* more nearly approach the *Rhynchonellidæ* than might appear on a first glance, and by the existence of these crura the *Orthidæ* are characterised as a truly transitional group, which link once more the *Aphaneropegmata* to the *Rhynchonellidæ* proper.

The crura are but very little developed in *Orthis* itself. More strongly, and even stronger than in most of the *Rhynchonellidæ*, are they developed in *Syntrielasma* or *Entelestes*, as the genus must more properly be called. The presence of such large crura has even induced Mr. Dall to place the genus *Syntrielasma* altogether in the family *Rhynchonellidæ*.

The existence of these crura, the smallness of the cardinal process in the dorsal valve, the occurrence of a more or less large area in both valves, with a large and always open deltidial fissure, all these characters serve to distinguish the family *Orthidæ* from the *Strophomenidæ* proper, and I think the distinction can very well be sustained also on geological grounds.

The family is a very small one, and there are only a few genera that can be placed in it. Nevertheless I am able to distinguish easily two sub-families. The first of these contains only one genus. I shall call it

#### Sub-family : *ENTELETINÆ*.

The genus of which this sub-family is composed is *ENTELETES*, Fisch. v. Waldh., a name which must replace the name *Syntrielasma*, Meek, now generally used for these forms. The accurate description of this genus will follow further on.

The second sub-family will bear the name

#### Sub-family : *ORTHINÆ*.

This sub-family is composed of the following genera :—

1. *ORTHIS*, Dalman, 1828 (Kongl. Vetensk. Acad. Handl., 1827, pp. 93, 96).

Crura very small, hingeline shorter than the greatest breadth of the shell; shell radially striated externally: cambrian to permian.

2. *BILOBITES*, Linné, 1775 (Syst. Nat., ed. Müller, VI., p. 325). Shell small, bilobed, with large, thin, wing-shaped crura in the dorsal valve: silurian and devonian.

3. *PLATYSTROPHIA*, King, 1850 (Monogr. Brit. Perm. Foss., p. 106). Crura as small as in *Orthis*, hingeline as long as or longer than the greatest breadth of the shell; shell externally strongly plicated radially: silurian.

4. *SKENIDIUM*, Hall, 1860 (13th Regents Rep. New York State Cab., p. 70, Dec. f. 2. 4. 5).=*Mystrophora*, Kays. *Orthis*-like, small, with a very large median septum in the dorsal valve: silurian and devonian.

5. *ORTHOIDEA*, Friren, 1875 (Bull. Soc. Hist. Nat. de Metz, 2de sér., cahier 14, p. 1, Pl. I, f. 1—6). Internal structure known only from internal pyritic casts, but seems not to differ much from that of *Orthis*. Externally the shell without radial striation; smaller valve without an area: middle-lias.

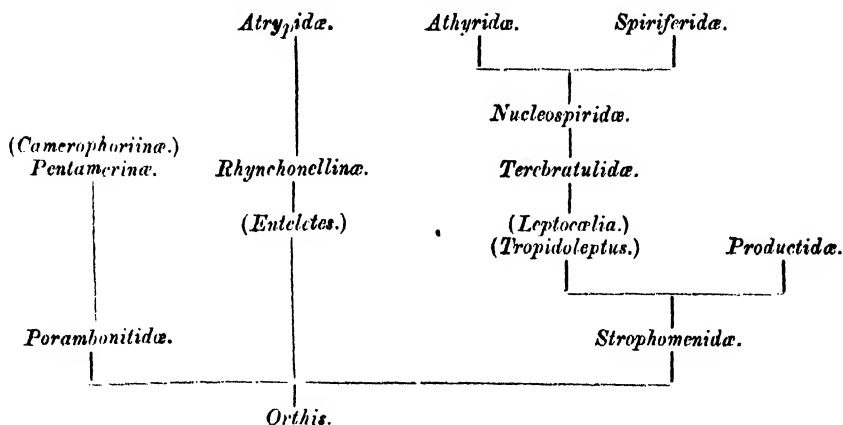
From this review of the genera it appears that the *Orthinae* range from the cambrian to the middle-lias, but that though the geological range is very extensive, yet the variety of forms is very limited. It cannot, however, be passed in silence that the geologically oldest known species of the *Arthropomata* belong to this sub-family, as the oldest known *Arthropomata* occurring in the cambrian period belong to the genus *Orthis*. This is the reason why it is of so much interest to point out the affinities between the *Orthidae* and other groups of *Brachiopoda*. I have already indicated above, in treating of the family *Porambonitidae*, that the affinity between this family and *Orthis* was very great; this is even the case to such an extent that I was for a long time in doubt whether I should not consider the *Porambonitidae* as a sub-family only of the *Orthidae*.

On the other hand, again, it has been pointed out that between *Orthis* proper and *Rhynchonella* there exists a certain affinity, which is chiefly marked in the genus *Euteletes*—a genus which has been united by Dall directly with the *Rhynchonellidae*. From these latter we come to the *Atrypidae*, which are considered by most authors as very nearly related to the *Rhynchonellidae*.

A third series of affinities exists between *Orthis* and the remainder of the *Aphaneropegmata*. There come first *Orthothetes*, *Streptorhynchus*, &c., which link the genus *Orthis* to *Strophomena*, and the near affinity of the latter genus to the *Productidae* has been demonstrated most recently by Neumayr, who detected the occasional occurrence of reniform impressions in *Strophomena*. From *Strophomena*, again, we pass through Hall's genera *Tropidoleptus* and *Leptocælia* (which show in general a certain affinity with *Strophomena*) to the *Terebratulidae* with an entire and complicated loop, and from these to the *Nucleospiridae*, *Athyridae*, and *Spiriferidae*.

It is, then, of great interest that the geologically oldest genus, *Orthis*, should be

the one from which all these affinities take their origin. If we bring these affinities into a tabular view we get the following scheme :—



This scheme is the key to the affinities of all the *Arthropomata*, with the exception of the *Thecideidæ* and the *Stringocephalidæ*. These two groups stand apart from the rest.

It is now very seducing to take this scheme as also representing the appearance in time of the different groups, and as showing their developmental connection. To a certain extent this may be in fact the case, but at all events the scheme shows what way the development of the *Arthropomata* may have taken to arrive at the more complicated forms of the *Rhynchonellidæ*, *Atrypidæ*, *Productidæ*, and *Terebratulidæ*, starting from the geologically oldest genus *Orthis*. The succession in time of the different groups does not oppose the idea of their being in a developmental connection; and as far as regards the *Porambonitidæ* and *Pentamerinæ*, such a connection has been advocated already by Noetling, but the direct proofs, the connecting species between the different groups, have in most cases not yet been detected, and we must look forward for them in the future.

In the Salt-range the family *Orthidæ* is represented by two genera—the sub-family *Enteletinæ* by the genus *Enteleles* and the sub-family *Orthinæ* by the genus *Orthis*.

#### Sub-family : ENTELETINÆ.

#### Genus : ENTELETES, Fisch. v. Waldb.

1830. *Enteleles*, Fischer von Waldheim : Oryctogr. du Gouv. de Moscou, p. 144., Pl. XXVI, figs. 6, 7.

1845. *Spirifer (lamarcki)*, Verneuil : Murch. Vern. Kays. Geol. of Russia, Vol. II., p. 152, Pl. 6, fig. 8.

1865. *Syntriclasma*, Meek : Proc. Acad. Nat. Sci., Philad., Dec., 1865, p. 277.; Geol. Rep., Illinois, Vol. II, p. 321, figs. 36, 37.

1876. *Orthis (lamarcki)*, Trautschold : Mjatschkowa, II, p. 70, Pl. VII, fig. 3.

1883. *Syntriclasma* (Meek), Kayser : Richthofen's China, Vol. IV, p. 179, Pl. XXIV, figs. 2, 3.

Though the characteristic of the genus, as given by Fischer von Waldheim, is very insufficient, yet the species, which is represented on Pl. XXVI, figs. 6 & 7 of his work, can very easily be recognised and identified with *Choristites* or *Spirifer*

or *Orthis lamarecki*—a species which is very characteristic for the upper carboniferous-limestone of Mjatschkowa, from which locality also the original specimen of *Enteletes* came.

Fischer von Waldheim characterises his genus in the following manner: "Coquille sub-arrondie ressemblant pour la forme à une Térébratule, présentant de petits becs sur les deux valves, mais la charnière est tellement unie et close, que les deux bords avancent un peu au dessus de la coquille.

"La charnière est très courte."

It is evident that this description was drawn up from a somewhat compressed specimen, in which the hinge-margin of one valve was shifted above that of the other—a mode of preservation which is not at all rare in the genus. But though we may make allowance for such a mode of preservation, yet it cannot be denied that the characteristic of the genus as given by Fischer von Waldheim is quite useless, and cannot in any way serve for the right understanding of what is to be taken as forming part of the genus.

Nevertheless the name *Enteletes* cannot be erased from the pages of scientific literature; and as it can be easily made out from the figure as well as from the locality whence came the original specimen of *Enteletes*, what was originally understood by the name, there is, I think, no escape from making use of it. It is, however, to be regretted that the shells which must bear the name of *Enteletes* are generically identical with what has been described by Meek under the name *Syntrielasma*. The genus has been very well characterised by Meek, and I should have gladly retained his designation, if it had been already in general use, and sanctioned by a long-continued practical application. This is, however, not the case, and the name has up to the present only been rightly applied by few people. Zittel, for instance, in his hand-book has entirely misunderstood Meek's genus: he quotes *Enteletes* as a sub-genus of *Orthis*, and refers *Syntrielasma* to the family *Porambonitidae*, though the two are identical. Under such circumstances, I think it best to go back to the old name *Enteletes*.

The genus *Enteletes* may be characterised as follows:—

The general outline of the shell is more or less globular, with mostly very strongly inflated valves. The hingeline is short, never projecting, both valves are more or less strongly plicated radially.

The ventral valve is always smaller than the dorsal one. The area of the ventral valve is sometimes high and strongly reclining, sometimes not; but laterally little extended, according to the short hingeline. It is cut open in the middle by a tolerably large triangular fissure, which is never covered up by a pseudodeltidium.

The dorsal valve is always larger than the ventral one, with a strongly bent over and sometimes even rolled-in beak. The area is mostly small in this valve, and even sometimes linear. The deltidial fissure is smaller than in the other valve.

Both valves are covered all over with a very fine radial striation, similar to that occurring in many species of *Orthis*, and it appears not improbable that also in

*Enteleles* fine hair-like spines were disseminated irregularly over this striation. The minute structure of the shell is punctate.

These are the external characters. Internally the ventral valve bears two strong elongated teeth on both sides of the triangular fissure, supported by very strong dental plates, which extend from the apex towards the front of the valve; but instead of diverging they approach each other towards the middle of the valve, bending round either with a gentle curve or with a sudden bend. Between these dental plates, beginning as a low ridge at the apex, a thin blade-like median septum extends; it is highest towards the middle of the valve, and then suddenly terminates (Pl. LVII, fig. 5b).

The dorsal valve has interiorly two very strong septa, which extend on both sides of the deltidial fissure and project for a certain distance, strongly diverging into the interior of the valve. They support strong and long curved crura, which have exactly the shape of a boar's tusks. They are laterally compressed, and bear on their lower and inner side a sharp prominent ridge. The dental sockets are placed exteriorly to the origin of the crura. In the middle, at the apex of the valve, a small cardinal process is observable, having the form of a short narrow ridge.

These characters will suffice to recognise the genus and to distinguish it readily from other allied forms.

The exterior shapes of the shells belonging to the genus are more or less variable, and chiefly remarkable in this respect is the shifting of the median sinus from one valve to the other, which to such an extent has only been observed besides in the genus *Pentamerus*.

There is one series of forms, the typical one, in which the sinus is on the ventral valve, and the dorsal valve bears a corresponding median fold. To this series belongs the *Enteleles glaber*, Fisch., and *Enteleles lamarcki*, Fisch., of Russia; and the *Enteleles hemiplicatus*, Hall, sp., from the upper coal-measures of America. This series is represented in India by two species—*Ent. kayseri*, W., and *Ent. levissimus*, W.

The other series, in which the median sinus is on the dorsal valve and the ventral valve bears the corresponding median fold, is composed of five Indian species, which all occur in the Salt-range. The South American species, *Ent. andii*, Orb., and *Ent. gaudryi*, Orb., cannot well be classed, as the septa characteristic of the ventral valve have not been observed, and thus it is not known for certain which valve is the ventral one. But that the series with a sinus in the dorsal valve is not entirely absent in America, appears highly probable from Geinitz's figure and description of his *Rhynch. angulata*, L., from Nebraska. The interior of the larger valve, which he figures Pl. III, fig. 2, beautifully represents the internal structure of the dorsal valve of *Enteleles*, and the fig. 1b, in which, as is distinctly stated by Geinitz, the smaller valve is above and the larger one below, shows beyond any doubt a median sinus in the larger, that is to say, in the dorsal valve. The peculiarities of these two groups can well be used for the distinction of two different

sections within the genus, the first of which I shall call the "*Ventrisinuati*," the second the "*Dorsosinuati*."

The Salt-range species are distributed through the middle and upper divisions of the Productus-limestone. The geologically oldest species is *Enteleles ferrugineus*, W., which occurs in the lower region of the middle Productus-limestone, and which is most nearly related to *E. andii*, Orb., and the species figured by Geinitz from Nebraska. Next come *Enteleles pentameroides*, W., and *Ent. sublavis*, W., from the middle region of the middle Productus-limestone, and then *Enteleles latesinuatus*, W., from the upper region of the middle Productus-limestone of Musakheyl. The geologically youngest species is *Ent. acuteplicatus* from the upper Productus-limestone.

All these species are very nearly related to each other, and in part most likely in developmental connection; I can distinguish two groups: the one starts from *Ent. ferrugineus*, W., and proceeds through *Ent. sublavis*, W., to *Ent. latesinuatus*, W.; the other takes its origin from *Ent. pentameroides*, W., and terminates in *Ent. acuteplicatus*, W.

The section of the *Ventrisinuati* commences with *Ent. kayseri*, W., in the middle region of the middle Productus-limestone, and terminates with *Ent. levissimus*, W., in the upper region of the same formation. It is probable that both species belong to a group of forms of which *Ent. hemiplicatus*, Hall., is the type.

## I. SECTION: VENTRISINUATI.

### A.—GROUP OF *ENTELETES HEMIPLICATUS*, Hall, sp.

#### 1. *ENTELETES KAYSERI*, Waagen: n. sp.

1882. *Syntriolasma hemiplicata* (Hall), Kayser, in Richthofen's China, Vol. IV, p. 179, Pl. XXIV, figs. 2, 3 (non Hall).

This species is very badly represented in the Salt-range collection, and it is only from a single ventral valve that I can state its occurrence there.

The truly beautiful figures of this species published by Professor Kayser, as well as his excellent description, make it easy to recognise the species even in a fragmentary condition, and I think the determination of the Indian specimen cannot be subject to any doubt. All the features indicated as characteristic of the Chinese shell are found again on the Indian specimen.

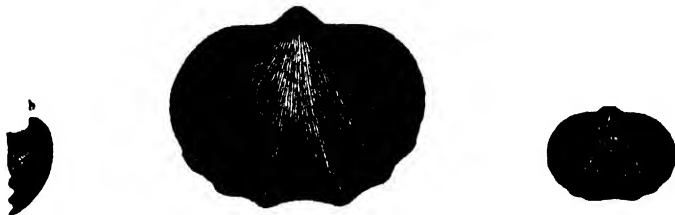


Fig. 13. *ENTELETES KAYSERI*, Waagen, n. sp. Ventral valve from the middle Productus-limestone of Swat. a, ventral view; b, lateral view, both natural size; c, ventral view, enlarged.



The ventral valve is comparatively flat, with a slightly bent-over apex, and a comparatively large triangular area, which is cut open in the middle by a deltidial fissure. The area is reclining and but very little concave. The valve is smooth for fully one-third of its extent, then a broad median sinus begins to appear, which is followed on each side by three short narrow folds. Of the three septa only traces can be discerned on the specimen at hand.

The radial striation of the shell is fine and distinct.

The measurements of the specimen are as follow :—

Entire length of the valve	.	.	.	.	.	.	.	.	13 mm.
" breadth " "	.	.	.	.	.	.	.	.	17 "
Height of the area	.	.	.	.	.	.	.	.	2.5 "
Apical angle	.	.	.	.	.	.	.	.	121°

*Locality and geological position.*—The only ventral valve of this species that is known to me was collected by Dr. Oldham at Swás in the middle region of the middle Productus-limestone.

*Remarks.*—This species was described originally by Professor Kayser from Lo-Ping in China from upper-carboniferous beds under the name of *Syntrielasma hemiplicata*, Hall. At the time of publication of Kayser's work no other species of *Syntrielasma* or *Enteleles* were known, except the above species of Hall, and *Syntrielasma lamarcki*, Fisch. Of these two species the first one is beyond doubt by far more nearly related to the Chinese shells than the other, and thus it is very well explainable how Mr. Kayser came to identify his specimens with Hall's species. Now, however, after so many species from the Salt-range are known to me, the range of variation of the single species can more easily be judged, and accordingly it seems highly probable that the Chinese shells represent a species different from *Ent. hemiplicatus*.

One of the differences has been indicated already by Mr. Kayser; this is the hingeline, which is considerably longer in the Chinese than in the American shell. Other differences consist in the much broader and less deeply sunk-in sinus of the ventral valve and in the sharper and narrower lateral folds. It needs only a comparison of the frontal view of both species to remark immediately the great differences that exist.

I therefore consider the Chinese and the Indian specimens as forming a species different from *Enteleles hemiplicatus*, and introduce for it the name of *Enteleles kayseri* in honour of its first describer.

## 2. ENTELETES LÆVISSIMUS, Waagen, n. sp.

This species is of rather small size, with nearly quite smooth valves, which are very little different in size, the dorsal valve being but little larger than the

ventral one. In its whole outward appearance this species approaches very near to *Orthis*.



Fig. 14. *ENTELETRIS LEVISSIMUS*, Waagen, n. sp. Specimen from the middle Productus-limestone of Bilot: *a*, ventral view; *b*, dorsal view; *c*, lateral view (the ventral valve to the right is much too small—see measurements); *d*, cardinal view, the ventral valve above,—the four figures natural size; *e*, ventral view enlarged.

The ventral valve is rather flat. Longitudinally its curve is considerably stronger in the apical than in the frontal region; the transverse curve, however, is very regular. The apex is strongly pointed and little bent over. The area is sharply defined and comparatively large, cut open in the middle by a large deltidial fissure. It is very strongly reclining and but little concave. The valve is entirely smooth for a little less than half its extent from the apex, then a shallow median sinus begins to appear and extends down to the front, but is not limited on both sides by elevated ridges. On each side of the sinus, a little distant from it, a very slight trace of a lateral rib is indicated. Otherwise the valve is entirely smooth.

The dorsal valve is but little larger than the ventral one, and considerably more vaulted, the curve being very regular in both directions. The apex is strongly bent over and pointed. It overhangs a small but very sharply defined area, which is nearly vertical, and cut open in the middle by a large deltidial fissure. The area is but little concave. This valve is entirely smooth for fully two-thirds of its extent from the apex. Then only a very low and rounded, rather broad median fold appears, and extends down to the front. It is followed on each side by a faint indication of a short, narrow, lateral fold. Otherwise the valve is entirely smooth with the exception of some more strongly marked striæ of growth which appear from distance to distance on both valves.

Of the interior characters of this species nothing is known to me.

The radial striation of the shell, which is characteristic of the genus, is very fine in this species.

The measurements of the only existing specimen are as follow:—

Entire length of the shell	14 mm.
Length of the ventral valve	13 "
Entire breadth of the shell	16.5 "
Length of the hingeline	8.5 "
Entire thickness of the shell	10 "
Height of the area in the ventral valve	3 "
" " " dorsal "	2 "
Apical angle of the ventral valve	115°
" " " dorsal "	107°

*Locality and geological position.*—The only specimen of this species that is known to me was collected by Mr. A. B. Wynne, at Bilot, trans-Indus, in the top-most beds of the middle division of the Productus-limestone.

*Remarks.*—This species appears to be rather nearly related to the one described before; there are nevertheless differences which led me to distinguish the present form specifically. These differences consist chiefly in the large area of the ventral valve, and in the presence of only one lateral fold on each valve, instead of three as in the preceding species. This cannot be a difference caused by difference of age, as in the specimen of *Ent. kayseri* from Swás, which is of equal size, all the folds are already developed, and as also according to Kayser's figures all the folds of *Ent. kayseri* were developed at the same time.

## II. SECTION: DORSOSINUATI.

### A.—GROUP OF *ENTELETES FERRUGINEUS*, Waagen.

#### 3. *ENTELETES FERRUGINEUS*, Waagen, n. sp.; Pl. LVII, figs. 7, 8.

There is no complete specimen of this species in the Salt-range collection; but the strong and comparatively sharp radial folds which, chiefly in the ventral valve, reach up to the apex, and by which the species can easily be recognised, make a distinction of it desirable.

The species is not large, not even quite of a medium size. It is transversely oval in outline, with the valves moderately inflated. The difference in size of the two valves is very small, and it appears from some fragments as if in this species the ventral valve sometimes exceeded slightly in size the dorsal one. The front margin of both valves forms a very strongly and sharply zig-zag line.

The ventral valve is moderately arched, somewhat flatter than the dorsal one. It bears in the middle a highly elevated median fold, which is followed on each side by three lateral folds. The median fold is the broadest and at the same time the highest of all; the lateral folds gradually diminish in height and breadth. The apex and area of the ventral valve are concealed by rocky matter. The valve is covered with sharp striæ of growth which bend up and down in zig-zag lines, as at the margin of the valve. They are chiefly heaped together near the margin, where they cause a kind of truncation to be formed. The fine radial striation characteristic of the genus is well and sharply developed in this valve.

Of the interior characters of the valve, the existence of the three septa can well be observed.

The dorsal valve is slightly more strongly vaulted than the ventral one, and seems also to be mostly larger than the other, but the difference in size is not considerable. It bears in the middle a tolerably broad and deep median sinus, which commences already at the apex of the valve. It is limited on both sides by high

and tolerably sharp folds, which are followed on each side by two other folds, and a very slight indication of a third. The lateral folds do not reach the apex of the valve. Also in this valve many zig-zag striæ of growth can be observed; they are, however, not so sharp as those of the other valve. The fine radial striation is identical on both valves. The area of this valve is narrow but very sharply defined and strongly concave. The deltidial fissure is wide, the apex of the valve apparently slightly truncated. Of the internal characters of this valve the extremely strong and massive crura are well observable. They are comparatively short and composed of two blades, one vertical, which limits the dental socket on the inner side, and one horizontal, which is fastened below to the vertical one, and projects laterally towards the deltidial fissure. These crura are fixed on their outer side to two strong diverging septa which support the dental sockets. The cardinal process in the middle of the apex is not well preserved.

I cannot give exact measurements of this species, as the materials at hand are too fragmentary to do so.

*Locality and geological position.*—There are altogether only two valves of this species known to me; both were collected by Mr. A. B. Wynne at Omarkheyl in the trans-Indus continuation of the Salt-range. The specimens are contained in a hard yellowish marble, which bears many silicious particles. These latter, if the rock is disintegrated by weathering, take a blackish-brown colour, and remain standing out on the surface, and this is the state in which the two valves are preserved. In the Salt-range proper this mode of preservation is characteristic of the lower division of the middle Productus-limestone, and therefore I think I shall not be very wrong in assigning a similar position to the specimens from Omarkheyl.

*Remarks.*—The species here under consideration is of special interest on account of its general resemblance to *Ent. andii*, Orb., from the upper carboniferous-limestone of Bolivia. The similarity between the two shells is in fact so great that I should have unhesitatingly united the two, if I could have found out whether the specimen figured by d'Orbigny was a dorsal or a ventral valve. If the latter were the case the identity would be highly probable, but otherwise the shell would belong to an entirely different section of the genus.

Also the shell figured by Geinitz from Nebraska under the name of *Rhynchonella angulata*, L., is rather similar to the species here under description. I have already stated above that this shell probably belongs to the section "*Dorsosinuati*," and so far it can be well compared to the Indian species. Nevertheless the two forms cannot be identified. The American shell is about as long as it is broad, and in both valves the folds begin only at a certain distance from the apex, both being characters which do not agree with those of the Indian species.

It is, however, of special interest to observe that the geologically oldest species of the Salt-range is the one which is most nearly related to the American coal-measure forms.

## 4. ENTELETES SUBLÆVIS, Waagen, n. sp. ; Pl. LVII, figs. 1 &amp; 3.

The general outline of the species is slightly broader than it is long ; the dorsal valve is considerably larger than the ventral one, and both valves are rather strongly inflated ; the smaller valve is nearly smooth, the larger rather strongly plicated.

The ventral valve is moderately inflated, much less so than the dorsal one, and its curve is tolerably equal in both directions. The apex is pointed and well bent over, with a small and not very distinctly defined area below, which is considerably concave. The deltidial fissure in the only specimens is covered by rock matter which could not be removed. The hingeline is very short, measuring barely more than half the transverse diameter of the shell. At the apex of the valve a low median fold, which is at first barely visible, begins to be formed, and extends down to the front line, but even in this vicinity it does not attain much size. Its breadth is also moderate. Lateral folds are almost quite absent, and only in the vicinity of the margin of the shell slight traces of two lateral folds appear. Otherwise the lateral parts of the valve are smooth. There are some more or less distinctly marked striae of growth disseminated over the valve. The radial striation is distinct when the shell is well preserved.

The dorsal valve is much more strongly inflated than the ventral one, but its curve is also tolerably equal in both directions. The apex is prominent and inflated, and very strongly bent over. It is a little truncated, forming a kind of small semi-circular foramen. The area is sharply defined but extremely narrow, nearly linear, and very strongly concave. At the very apex of the valve there commences already a distinct, tolerably broad and deep median sinus, which gets more and more strongly marked as it approaches the frontal margin. It is limited on both sides by prominent and strongly marked rounded folds. These are followed again by two well marked, rounded lateral folds on each side. These latter do not however commence immediately at the apex, but at a more or less considerable distance from it. Young specimens in consequence appear nearly quite smooth, with the exception of the median sinus in the dorsal valve.

Of the internal characters the three ventral and the two diverging dorsal septa can be very well seen in a young specimen.

The dimensions of two specimens are as follow :—

	I.	II.
Entire length of the shell . . . . .	28 mm.	15·5 mm.
Length of the ventral valve . . . . .	20·5 "	14 "
Entire breadth of the shell . . . . .	24 "	17·5 "
Length of the hingeline . . . . .	13 "	9 "
Entire thickness of the shell . . . . .	21 "	12 "
Apical angle of the ventral valve . . . . .	10·5°	10·7°
" " " dorsal valve . . . . .	88°	90°

*Locality and geological position.*—There have altogether two specimens of this species been found up to the present, which were collected by Mr. Wynne. The

largest of them comes from hard limestones of the Chittawán, forming there the middle region of the middle Productus-limestone. The second specimen was collected at Shekh Budín (trans-Indus). It is contained in a hard grey limestone, forming probably also part of the middle division of the Productus-limestone.

*Remarks.*—This species on a first glance seems to be rather similar to *Enteletes hemiplicatus*, Hall, sp., but on closer examination one soon finds that the American species has its sinus in the ventral valve, whilst the Indian shell has it in the dorsal one, and thus a comparison between the two shells can in reality not be undertaken.

From *Enteletes ferrugineus*, W., the present species can be distinguished easily by its nearly quite smooth ventral valve, whilst in the former one the same valve is strongly plicated.

### 3. ENTELETES LATESINUATUS, Waagen, n. sp.; Pl. LVII, figs. 4, 5, 6.

This is a rather large species of slightly transversely oval outline, moderately inflated valves, of which the ventral one is by far the flatter, and with an extremely broad median sinus in the dorsal valve.

The ventral valve is flat, obliquely conical, but very little arched in both directions. The apex is little prominent and barely at all bent over. The area is high and strongly reclining, but very little concave. The deltidial fissure is large, somewhat higher than it is broad, occupying just one-third of the entire area, which is very short in comparison to its height, the hingeline not being longer than half the transverse diameter of the shell. Immediately at the apex there begins a high and very broad median fold, which becomes so broad as to occupy the entire front of the shell. This fold is narrowly rounded on the top and in consequence somewhat roof-shaped. On each side of this median fold there is a lateral one, which is, however, low and little developed, although commencing also very near the apex of the valve. The remainder of the valve, up to the margins of the area, is smooth and gently vaulted. The fine radial striation is not very well visible on the outer surface of this species, owing to the somewhat coarsely silicified condition of the specimens.

The dorsal valve is very much more strongly vaulted than the ventral, and its inflation is about equal in both directions; it is also considerably larger than the ventral valve. The apex is enormously inflated and strongly bent over, and owing to a strong truncation it bears a large semi-circular foramen at its end, within which a small cardinal process is visible. The area is very small, nearly linear, and so strongly concave that it makes a nearly angular bend. In the immediate vicinity of the apex there commences the enormously broad and deep median sinus, which expands so as to occupy the whole frontal part of the valve. The sinus is bordered on both sides by narrowly rounded elevated ridges, which are followed laterally again by low folds, one on each side. The rest of the valve is smooth, sometimes perhaps with a very slight indication, near the margin, of a second lateral fold.

The internal characters could be well studied in one of the silicified specimens, and have been figured, Pl. LVII, figs. 5 and 6. In the ventral valve the three septa are very conspicuous features. The two lateral ones support the hinge-teeth, which are formed by the direct continuation of a thickened shelly ridge bordering the deltidial fissure; the median septum commences at the apex as a low shelly ridge, and ascends slowly to a high angular point, when it suddenly terminates (fig. 5*b*). The muscular impressions are probably situated between these septa, but they could not be observed.

In the dorsal valve the deltidial fissure is hemmed in by thick shelly ridges, which hang tolerably far down into the interior of the valve, making the same bend as is indicated by the concavity of the area. They do not, however, stop at the hinge-margin, but proceed far above it, expanding at the same time a little, and thus forming the curious kind of crura which imitate to a certain extent the shape of boars' tusks. Laterally, by their exterior side, these crura are fixed to strong diverging septa that originate near the apex of the valve and support the dental sockets, which latter are situated on the external side of the crura, where they project from the hinge-margin. In the middle of the apex an elongated ridge-like cardinal process is observable; lower down this cardinal process changes into a slightly elevated shelly line, which extends about as far as the lateral septa.

In this valve also the muscular impressions could not be distinguished.

The measurements of a specimen from Musakheyl are as follow:—

Entire length of the shell	.	.	.	.	.	.	.	.	34 mm.
Length of the ventral valve	.	.	.	.	.	.	.	.	29 "
Entire breadth of the shell	.	.	.	.	.	.	.	.	37 "
Length of the hingeline	.	.	.	.	.	.	.	.	19 "
Entire thickness of the shell	.	.	.	.	.	.	.	.	27 "
Height of the area of the ventral valve	.	.	.	.	.	.	.	.	8 "
Apical angle of the ventral valve	.	.	.	.	.	.	.	.	112°
" " " dorsal valve	.	.	.	.	.	.	.	.	84°

*Locality and geological position.*—There are altogether five specimens of this species known to me, of which two were collected by Dr. Warth at Musakheyl in the upper region of the middle Productus-limestone, two were found by Mr. Wynne in the Chittawán in a similar geological position, and one specimen I brought myself from Virgal, where it occurred in the coral beds of the middle Productus-limestone.

*Remarks.*—This beautiful species is rather nearly related to the two previously described, but from both it can be easily distinguished by the peculiar configuration of its ventral valve, which is nearly quite flat, and has a beak that is not bent over, in consequence of which the area of that valve is scarcely at all concave. Other distinguishing characters are the scarcity of ribs and the enormously broad median sinus in the dorsal valve. From these characters it appears that the present form is an easily distinguishable species.

Of other species none can be compared particularly to the present one.

B.—GROUP OF *ENTELETES PENTAMEROIDES*, W.6. *ENTELETES PENTAMEROIDES*, Waagen, n. sp. ; Pl. LVII, fig. 2.

This is the largest species of *Enteleles* that has been detected up to the present. The shell is about as long as it is broad, with extremely inflated valves, so as to be almost globular. Both valves are very strongly plicated.

The ventral valve is by far smaller than the dorsal one. It is very strongly arched, but more so in the longitudinal than in the transverse direction. The apex is well bent over, but it remains doubtful whether it is truncated or not. The area is high and very strongly reclining, flat for the greater extent along the hingeline, and strongly concave where the apex overhangs it. It is cut open in the middle by a large deltidial fissure. The hingeline is rather short. At a very little distance from the apex a median fold appears, which extends down to the front, but which is never very prominent or conspicuous. It is followed on each side by four lateral folds, which are not much less strong than the median one. They diminish in size the more they are removed from the median fold. The dorsal valve is very considerably larger than the ventral one, and chiefly the apical region projects far above the hingeline. Also the inflation is about twice as strong as that of the ventral valve; the curvature is, however, about equal in both directions. The apex of the valve is very strongly bent over, and almost entirely rolled in. It cannot therefore be exactly seen whether the apex is truncated or not. The area is very narrow and very strongly concave. A median sinus appears to commence directly at the apex and to extend down to the front line. It is neither very broad nor very deep, and not very distinct from the furrows which separate the other radial folds from each other. The sinus is shut in on both sides by rather high ridges, which are broadly rounded on the top and are more prominent than the remaining radial folds. These ridges are followed on each side by three to four radial plications, which gradually diminish in size, as they are moved from the median part of the valve.

Both valves are marked by concentric plications or striæ of growth, which are most strongly marked on the top of the radial folds, and are mostly restricted to the vicinity of the margins of the valves. The fine radial striation characteristic of the genus is less strongly marked in this species than in those previously described.

Of the internal characters of this species nothing is known to me.

The measurements of the only existing specimen are as follow :—

Entire length of the shell	. . . . .	39 mm.
Length of the ventral valve	. . . . .	30.5 ..
Entire breadth of the shell	. . . . .	39 ..
Length of the hingeline	. . . . .	24 ..
Entire thickness of the shell	. . . . .	37 ..
Height of the area of the ventral valve	. . . . .	8 ..
Apical angle of the ventral valve	. . . . .	114°
" " " dorsal valve	. . . . .	77°



*Locality and geological position.*—The only specimen of this species preserved in the Salt-range collection was found by myself in white, somewhat dolomitic, limestone forming part of the middle region of the middle Productus-limestone in the vicinity of Katwáhi.

*Remarks.*—This species is chiefly remarkable on account of a certain similarity it bears to *Enteleles lamarchi*, Fisch., from the upper carboniferous-limestone of Prussia, though the latter belongs to the section "Ventrinuati" as indicated above. The excellent figures given by Trautschold in his memoir on the carboniferous-limestone of Mjatschkowa show in the middle of the ventral sinus an elevated fold, which originates at the apex of the ventral valve, whilst on the apex of the dorsal valve a sinus originates corresponding to the fold in the middle of the ventral sinus. If we now suppose that this median fold were to increase considerably in size, we should without much difficulty arrive at the figure as exhibited by *Ent. pentameroides*. It needs only a comparison of the figure, Pl. LVII, fig. 2*d*, of the present work, with that given by Trautschold in his monograph, Pl. VII, fig. 3*f*, to see how easily one form could have been changed into the other. Thus it becomes very probable that *Ent. lamarchi* is the ancestor of our *Ent. pentameroides*.

Of other species those described on the foregoing pages must be compared. The present form can be easily distinguished from all those by the much more prominent apical region and the narrower sinus of the dorsal valve and by the far stronger plication exhibited by both valves.

#### 7. ENTELETES ACUTEPLICATUS, Waagen, n. sp.; Pl. XLIX, fig. 10.

This species is considerably smaller than the preceding one, but otherwise not dissimilar. The general outline is considerably higher than broad, the dorsal valve being by far larger than the ventral one, and at the same time also much more inflated. Both valves are covered with very sharp and high radial folds.

The ventral valve is elevated conical, with a tolerably strong bend in both directions. The apex is pointed, not strongly bent over, and overhangs a large, nearly flat triangular area, which is so strongly reclining that it forms an acute angle with the plane of the valve. The deltidial fissure of the specimen is covered up by rock-matter. Immediately at the apex a median fold, which is high and angular, originates and extends down to the front. It is not much more prominent than the lateral folds which follow on each side. There are three to four of these folds on each side, which become gradually less prominent as they are more removed from the middle of the valve. The frontal margin of the valve forms a very strongly indented zig-zag line.

The dorsal valve is very much larger than the ventral one; it is also more strongly inflated, and therefore its curve is also more considerable in both directions. The apex is very much bent over and strongly inflated, the area below it very small and very concave. The deltidial fissure cannot be observed. At the apex there begins a deep and angular median sinus, which is, however, comparatively narrow.

On both sides of it narrow, angular, elevated ridges are situated, followed by three lateral folds diminishing gradually in size.

The radial striation of the shell is not preserved in this species, but the punctuation can yet be seen in some places.

It is difficult to give measurements of the only existing specimen, as it is much deformed by pressure; so far as observable, they are as follow :—

Entire length of the shell, about . . . . .	33 mm.
Length of the ventral valve . . . . .	21 "
Entire breadth of the shell . . . . .	29 "
Length of the hingeline . . . . .	16 "
Entire thickness of the shell, about . . . . .	23 "
Height of the area of the central valve . . . . .	5 "
" " " " dorsal valve . . . . .	3 "

*Locality and geological position.*—The only specimen of this species that is known to me was found by myself in the vicinity of Katwáhi in the upper division of the Productus-limestone.

*Remarks.*—The specimen upon which the present species is founded would not have been worth describing, its state of preservation is so bad, were it not that it represents the geologically youngest form of the genus *Enteleles* that has been observed up to the present. On account of this special interest, I have ventured to describe it under the above name. Even in its bad state of preservation the specimen can easily be recognised as representing a form very nearly related to *Ent. pentameroides*, W., but yet different from it. The differences consist chiefly in the strong and angular folds of both valves and in the more strongly reclining area of the ventral valve. The similarities on the contrary are to be sought for in the narrowness of the sinus in the dorsal and the little prominence of the median fold in the ventral valve.

From these circumstances it appears highly probable that though *Ent. pentameroides* may be the ancestor of *Ent. acuteplacatus*, yet the latter forms a well distinguishable separate species.

#### Sub-Family : ORTHINÆ.

#### Genus : ORTHIS, Dalm.

I accept this genus in the most restricted sense, as it has been circumscribed by Davidson and others, and think that it is most strictly characterised by the existence of two short crura in the dorsal valve. All the other forms formerly classed with *Orthis*, such as *Streptorhynchus*, *Orthisina*, &c., are entirely devoid of such crura, and instead of them the cardinal process, which is but little developed in *Orthis* proper, attains a development which already to a certain extent suggests the development of that part in the family *Productidæ*. I therefore not only exclude those forms from the genus *Orthis*, but altogether remove them from the family *Orthidæ*, uniting them at the same time with the family *Strophomenidæ*.

I have no new observation as to the internal structure of the Indian shells belonging to the genus, as the preservation of the materials is not propitious for such observations. Moreover, the species of *Orthis* are rather rare in the Salt-range; only at one locality, Amb, have many specimens of *Orthis* been found, in the lowest beds of the Productus-limestone.

Altogether seven species of *Orthis* have been detected in the Salt-range, assignable to three groups, differing in their internal arrangement. The first group is that of *Orthis morganiana*, Derby. This group forms a transitional link between *Orthis* proper and *Enteleles*. The interior structure of these forms has been very ably described by Mr. Derby. As in *Enteleles* there are two strong, curved up, horn-shaped crura, supported by strong diverging septa, in the dorsal valve, and three elevated ridges in the ventral one; but all these characters are much less strongly developed than in *Enteleles*, and chiefly the internal arrangement of the ventral valve approaches much nearer to that occurring in typical species of *Orthis* than to that of *Enteleles*. I thus think it more correct to retain these species in *Orthis* than to place them among the *Enteleles*. There are two species of this group in the Salt-range, which will bear respectively the name of *Orthis marmorea*, W., and *Orth. derbyi*, W.

For a second group the *Orthis resupinata*, Mart., is the type. The interior of the shells belonging to this group has been admirably described by Davidson. The differences from the preceding group consist chiefly in the less strong development of the crura and their shelly supports in the dorsal valve, and in the little development of the median ridge in the ventral one. This group is represented in the Salt-range also by two species, which will bear the names of *Orthis indica*, W. (= *Orth. resupinata*, Dav.), and *Orthis janiceps*, W.

The third group is typified by *Orthis michelini*, Lév. For the description and drawing of the interiors of the shells belonging to this group, we are again indebted to the admirable investigations of Mr. Davidson. The species of this group are chiefly different from those of the preceding one by the arrangement of their muscular impressions and by the interior character of the ventral valve. Whilst in *Orthis resupinata* and its allies there exists still a little developed median ridge in the ventral valve, this ridge is nearly quite absent in *Orth. michelini*. The species belonging to this group can also exteriorly be easily recognised by their elongated general outline and the extraordinarily short hinge-margin. This group is represented in the Salt-range by three species—*Orthis corallina*, W., *Orthis pecosii*, Marcou, and *Orthis incisiva*, W.

It cannot be denied that the three groups just indicated do not exactly correspond to what has been called generally in this work a "group;" these groups rather correspond to the "divisions" as introduced by me in other genera, or they might be even of sub-generic value. The reason why I called them simply groups is, that it is impossible for me to work up the whole host of species of *Orthis* existing in the devonian and silurian periods, partly on account of lack of materials, and partly on account of the impossibility to spend the necessary time on the subject;

but without a careful study including these older forms a definite sub-division of the genus cannot be arrived at. I thus did not like to prejudice by divisional or sub-generic names a future monographical treatment of the genus.

I.—GROUP (OR SUB-DIVISION) OF *ORTHIS MORGANIANA*, Derby.

1. *ORTHIS DERBYI*, Waagen, n. sp.; Pl. LVI, figs. 2, 5, 6.

This species is of a middle size and does not seem to become large. Its general outline is nearly circular or transversely oval, the dorsal valve being considerably larger and more inflated than the ventral one. The latter valve bears a flat sinus in the middle.

The ventral valve is more or less conical, with a flat curve in the longitudinal and a very small curve in the transverse direction. The hingeline is very short; the area high, very strongly reclining, but very little concave and cut open in the middle by a very large triangular fissure, which is just as broad at its base as it is high. The area is tolerably sharply defined. The apex of the valve is very pointed, but very little bent over, and only slightly overhanging the deltidial fissure. Not far from the apex a median sinus begins, and extends down to the front, indenting the dorsal valve. The lateral parts of the valve are smooth.

The dorsal valve is much larger and more strongly inflated than the ventral one. Longitudinally its curve is much stronger in the apical than in the frontal region. Transversely the curve is strong but not equal; there is a kind of median carination of the valve observable extending from near the beak to the front, and on both sides of which the valve is somewhat flattened. The area is small, very sharply defined, and distinctly overhanging the area of the other valve. It is but little concave and cut open in the middle by a large triangular fissure. The apex of the valve is not complete, but truncated, whereby a kind of semi-circular foramen is formed, within which the small cardinal process is visible.

The surface of both valves is covered by strong imbricating striae of growth, which form approximately a semi-circle in the ventral valve, but which are indented in passing over the median carination of the dorsal valve. The whole shell-surface is provided with a very fine radial striation, similar to that occurring in *Orthis resupinata*.

Of the interior characters of the species only those of the ventral valve are known to me, and these only partially. The specimen showing them is figured, Pl. LVI, fig. 2. The hinge-teeth are supported by very strong dental lamellæ, which are continued in the direction of the front as diverging, somewhat elevated, ridges up to a short distance from the front, then they suddenly bend round towards the middle and unite with a sharp but not very elevated median ridge, which latter does not, however, extend quite up to the apex of the valve. By these ridges two deep elongately oval grooves are circumscribed which evidently served for the insertion of the divaricator and adductor muscles, but the sub-division of these grooves cannot

be distinctly seen. A slight impression runs longitudinally about the middle of them, but I cannot be certain whether this indicates the limit between the two pairs of muscles. The whole apparatus has very much resemblance to the same apparatus in the ventral valve of *Orthis resupinata*, but is comparatively very much larger than in that species.

The measurements of two specimens, No. I from the middle Productus-limestone of the Chittawán, and No. II from the uppermost bed of the upper Productus-limestone of Virgal, are as follow :—

	I.	II.
Entire length of the shell . . . . .	25 mm.	24 mm.
Length of the ventral valve . . . . .	21 "	21 5 "
Entire breadth of the shell . . . . .	26 "	27 "
Length of the hingeline . . . . .	11 "	11 "
Entire thickness of both valves . . . . .	18 5 "	17 5 "
Height of the area of the ventral valve . . . . .	4 "	5 "
" " " " dorsal valve . . . . .	1 5 "	1 "
Apical angle of the ventral valve . . . . .	109°	121°
" " " dorsal valve . . . . .	89°	96°

*Locality and geological position.*—There are altogether six specimens of this species known to me which range from the middle division to the topmost beds of the upper division of the Productus-limestone. Two specimens were found by Dr. Oldham and Mr. Wynne in the middle Productus-limestone of the Chittawán, and one specimen in the same division in the Bazárwán also by Mr. Wynne. By myself the species has been collected at Virgal in the coral-beds of the middle division of the Productus-limestone (two specimens), and one more specimen also at Virgal in the topmost beds of the upper division of the same formation.

*Remarks.*—This species is easily distinguishable from all the European forms of *Orthis*, to any of which it has not even a remote similarity. So much the more marked is its resemblance to the South American *Orthis morganiana*, Derby, from which, in fact, it is not quite easily distinguishable. Nevertheless there are some points of difference which prevented my uniting the Indian form specifically with the South American one. The chief differences consist in the smaller size, the comparative thickness of the shell, the obtusely carinated condition of the dorsal valve, the truncated beak of the same valve, and the imbricating striæ of growth which cover both valves in the Indian species. These differences seem to me perfectly sufficient for the specific distinction of the two forms.

I have called this species *Orthis derbyi* in honour of Prof. Derby, to whose excellent description of the Brachiopoda of Itaituba I owe much most valuable information.

## 2. ORTHIS MARMOREA, Waagen, n. sp.; Pl. LVI, figs. 3, 4.

The materials of this species are very scanty indeed, but still sufficient to characterise the shell as a new and well distinguishable form.

The general outline of the species is transversely oval or somewhat triangular, the greatest breadth being situated far down in the vicinity of the front. The dorsal valve seems to be larger than the ventral one, but I am not quite certain on the point, as I have only one isolated ventral valve for observation. The dorsal valve is not much inflated, and the ventral one even very flat.

The ventral valve is very little arched in both directions, and its curve is very regular. The apex is but little elevated, pointed, and little bent over. The hinge-line is rather short, the area not very high, triangular, flat, not at all concave, and but little reclining, forming an angle of  $120^{\circ}$  with the plane of the valve. It is cut open in the middle by a large triangular fissure, which is about as broad at its base as it is high. The surface of the valve is entirely smooth, without the slightest indication of a median sinus, and thus the frontal and lateral margins of the valve lie all in one plane, forming a gentle, and in the frontal region somewhat flattened, curve.

The internal characters of this valve can be beautifully observed in a specimen from the Bazárwán. The strongly developed cardinal teeth are situated on both sides of the triangular fissure, and are supported by oblique shelly septa, which are angularly cut out immediately at and below the teeth. They descend in a gentle curve down to near the front, becoming gradually lower, and then disappear. In the middle of the valve, beginning from the apex and being highest in the centre of the valve, a strongly elevated median septum is situated, very much resembling that in *Enteleles*, but in not quite so extreme a development. It suddenly decreases in height after having reached the centre of the valve, and then bifurcates; the bifurcating branches extend only for a short distance and then disappear without quite uniting with the termination of the two lateral septa. The arrangement of the muscular scars cannot be exactly traced.

The dorsal valve is more strongly vaulted than the ventral one, but nevertheless its inflation is not very considerable. It is regularly curved in both directions, and its apex is not more strongly inflated than the remainder of the valve. The apex is strongly bent over and well pointed. The area is narrow, very sharply defined, and strongly concave, cut open in the middle by a large deltidial fissure. The surface of the valve is entirely smooth, only very faint striæ of growth being observable. The margins of the valve, lateral as well as frontal, are all in one plane, an indentation of the front by the ventral valve being altogether absent.

Of the interior characters of this valve only the existence of two diverging septa, the shelly supports of the crura, can be traced. In extent and position these septa seem to be very similar to those that have been described in the genus *Enteleles*.

The surface in both valves is covered by a radial striation, which is so fine that it is scarcely possible to observe it with the naked eye. Between this striation tolerably numerous large roundish foramina are strewn irregularly over the whole shell. On them were probably situated fine hair-like spines.

The substance of the shell is rather thick and heavy.

The measurements of a dorsal valve from Virgal are as follow :—

Entire length of the valve	. . . . .	30	mm
Length of the hingeline	. . . . .	18	„
Entire breadth of the valve	. . . . .	33	„
Entire thickness of the valve	. . . . .	14	„
Height of the area	. . . . .	3	„
Apical angle	. . . . .	110°	

A ventral valve from the Bazárwán, belonging to a somewhat smaller individual, exhibits the following dimensions :—

Entire length of the valve	. . . . .	25	mm.
Length of the hingeline	. . . . .	16	„
Entire breadth of the valve	. . . . .	29	„
„ thickness „	. . . . .	8	„
Height of the area	. . . . .	6	„
Apical angle	. . . . .	124°	

*Locality and geological position.*—There are altogether three specimens of this species known to me—two dorsal valves, one of which was collected by Dr. Oldham in the Chittawán, the other was found by myself in the coral-beds of Virgal; and one ventral valve brought by Mr. Wynne from the Bazárwán—all three specimens coming out of the hard, marbly, silicious limestones of the middle region of the middle Productus-limestone.

*Remarks.*—The species here under consideration is rather nearly related to the preceding *Orthis derbyi*, W., as well as to *Orthis morganiana*, Derb.

From the first it can easily be distinguished, by its much less inflated valves, the absence of a sinus in the ventral, and an indentation in the dorsal, valve, and by the absence of imbricating striæ of growth.

From the second it can be distinguished also by much less inflated valves, its heavy shell, and the absence of sinus and indentation in the ventral and dorsal valves.

## II.—GROUP (OR SUB-DIVISION) OF *ORTHIS RESUPINATA*, Mart.

### 3. *ORTHIS INDICA*, Waagen, n. sp.; Pl. LVI, figs. 7, 8, 14, 15, 16.

1862. *Orthis resupinata* (Mart.), Davidson : Quart. Journ. Geol. Soc., Lond., Vol. XVIII, p. 31, Pl. 1., fig. 15

1863. *Orthis resupinata* (Mart., Dav.), Koninck : Fossiles paléoz. de l'Inde, p. 37, Pl. X., fig. 15.

This species remains always very small; specimens of the size of the one figured by Davidson are the largest that have been observed up to the present.

The general outline of this species is mostly transversely oval, sometimes nearly circular, and rarely longer than it is broad. Of the two valves the ventral one is always the larger. The two valves are mostly about equally inflated. On the whole the species is, however, rather variable.

The ventral valve is the larger of the two. It is tolerably inflated, but its curve is not very regular, being rather inflated in the apical region and extending from there in a more flattened curve to the front. Transversely the curve is more regular. The beak is strongly incurved and pointed. It is bent over a small but tolerably high triangular area, which is strongly concave, and cut open in the middle by a moderately large deltidial fissure. The hingeline is short and not projecting on both sides. The surface of the valve is smooth, without a trace of a sinus or carination. The frontal margin is always strongly indented by the projecting frontal part of the dorsal valve.

The dorsal valve is always, but generally only very little, smaller than the ventral one; it is mostly also slightly more inflated. Longitudinally its curve is more regular than that of the other valve, but in the transverse direction it appears somewhat flattened in the middle, and then suddenly bends down to the lateral margins. The beak is strongly bent over and pointed. The area is small, very low, vertical and very sharply defined, cut open in the middle by a moderately large deltidial fissure. The valve is provided with a median sinus or impression which is mostly limited to the vicinity of the front in the specimens coming from the lower Productus-limestone, but reaches up to the apex in the specimens from the middle Productus-limestone. The frontal part of the valve projects a little and indents distinctly the corresponding part of the ventral valve.

On both sides slightly imbricating striæ of growth are to be observed. The fine radial striation which covers the whole shell is exactly like that in *Orthis resupinata*.

The interior structure of this species is altogether unknown to me.

The measurements of three specimens, No. I from the middle Productus-limestone of Katwáhi, and Nos. II and III from the lower Productus-limestone of Amb, are as follow :—

	I.	II.	III.
Entire length of the shell . . . . .	18 mm.	15·25 mm.	14 mm.
Length of the dorsal valve . . . . .	17·5 "	15 "	13·9 "
Entire breadth of the shell . . . . .	20 "	16 "	13·75 "
Length of the hingeline . . . . .	12 "	9 "	8 "
Entire thickness of the shell . . . . .	14·5 "	12 "	12 "
Height of the area in the ventral valve . . . . .	2 "	2 "	2 "
" " " " dorsal " . . . . .	1·5 "	1 "	1 "
Apical angle of the ventral valve . . . . .	108°	105°	90°
" " " " dorsal " . . . . .	114°	112°	97°

*Locality and geological position.*—This species ranges through the lower and middle divisions of the Productus-limestone; in the upper division it has not been found up to the present. The greatest number of specimens was collected by me at Amb in the coaly sandstones at the very base of the Productus-limestone proper, above the lavender-clays (twenty-two specimens). In somewhat higher beds I found it at Katta, in the lowest strata of the compact limestones (one specimen). In the mountains east of Katwáhi, I detected the species in the middle region of the



compact limestones in a silicified condition (four specimens) and at Virgal in the coral-beds associated with *Orthis derbyi* and *Orth. marmorea* (one specimen). The geologically youngest exactly determinable specimen I collected near Khura in the upper region of the limestones forming the middle division of the Productus-limestone.

From the trans-Indus continuation of the Salt-range, one specimen was contained in Dr. Verchere's collection. It is preserved in a grey sandstone, but the exact locality where it came from is not known.

*Remarks.*—This species has been described by Mr. Davidson under the name of *Orthis resupinata*, Mart., but I think the forms from the Salt-range can be distinguished from Martin's species. Mr. Davidson had only two specimens at his disposal, and therefore could not state the constant recurrence of certain characters, which is very striking when a greater number of specimens is accessible for observation.

In the first place it is a remarkable fact that specimens of many sizes occur, but never larger than those figured by Davidson in the Quarterly Journal, and by myself in this work, Pl. LVI, fig. 8. The species evidently did not grow larger, and there is no conceivable reason why *Orthis indica* should always be of small size, whilst *Orthis derbyi* and *marmorea* should have grown in the same beds and at the same localities to considerable dimensions. We evidently have to deal here with a small form which never attained the dimensions of *Orthis resupinata*.

Another very characteristic feature consists in the circumstance that the dorsal valve *always* indents the ventral one, so that the front line bends down towards the ventral valve, instead of, as is the case in *Orthis resupinata*, being curved up towards the dorsal one. This seems the most essential point of difference between the two species, which chiefly led me to distinguish specifically between them.

Specimens of *Orthis resupinata* of a size equal to the largest specimens of *Orthis indica* have mostly less inflated valves, a more marked transversely oval general outline, and a frontline which is always more or less strongly bent up towards the dorsal valve. Even in specimens in which the dorsal valve is flattened or slightly impressed in the middle this curve upward is not entirely eliminated.

I therefore think that the Indian specimens can well be considered as forming a species different from *Orthis resupinata*, for which I introduce the name of *Orthis indica*, W.

#### 4. ORTHIS JANICEPS, Waagen, n. sp.; Pl. LVI, fig. 9.

The species which I describe under the above name is about of the same size and general appearance as the preceding one, but can be distinguished on a close examination by the existence of a sinus in both valves, and by the dorsal valve being larger than the ventral one.

The general outline is transversely oval, with moderately inflated valves, of which the dorsal one is deeper.

The ventral valve is tolerably elevated in the apical region, but its curve is rather unequal. Longitudinally the curve is pretty strong in the vicinity of the

apex, and flattens considerably towards the front. In the transverse direction, however, the curve is rather regular. The apex is pointed and strongly bent over. The area is comparatively large, distinctly concave, and very strongly reclining, cut open in the middle by a not very large deltidial fissure. From near the apex there extends a flat, little impressed sinus along the middle of the valve down to the front. This valve is very slightly indented in the frontal region by the dorsal valve.

The dorsal valve is more strongly inflated than the ventral one, and also slightly larger. The longitudinal curve is very strong in the apical region and considerably flattened towards the front. Transversely the curve is somewhat flattened in the middle and strongly bent down on the lateral parts. The apex is much inflated, considerably bent over and pointed. The area is distinctly defined and very narrow, cut open in the middle by a very large deltidial fissure. Very near the apex there begins a longitudinal median sinus, which is more strongly impressed and broader than that of the other valve. The frontal part of the valve projects a little, causing a slight indentation of the same part of the opposite valve.

The interior characters of this species are not known to me.

The fine radial striation which covers both valves is exactly like that occurring in *Orthis resupinata*.

The measurements of a specimen from Katwáhi are as follow :—

Entire length of the shell	. . . . .	15 mm.
Length of the ventral valve	. . . . .	11.5 "
Entire breadth of the shell	. . . . .	17.5 "
Length of the hinge-line	. . . . .	8 "
Entire thickness of the shell	. . . . .	11 "
Height of the area of the ventral valve	. . . . .	2 "
" " " dorsal	" . . . . .	1 "
Apical angle of the ventral valve	. . . . .	108°
" " dorsal	" . . . . .	105°

*Locality and geological position.*—There are only two specimens of this species preserved in the Salt-range collection, which were both found by myself in the mountains east of Katwáhi in the middle region of the middle Productus-limestone together with *Orthis indica*, W., described before.

*Remarks.*—The two specimens by which the species is represented are not easily distinguishable from the very similar *Orthis indica*, and it was only after a careful study and comparison that I came to distinguish between the two forms. It is true the sinus in both valves is an easily observable feature, but if this were the only means by which the present form were distinguishable from *Orthis indica*, it would be very doubtful whether a specific distinction between the two forms could be advocated. Only after I had detected another peculiarity, which consists in the ventral valve being the smaller one, in opposition to the characters occurring in *Orthis indica*, I became certain that a specific distinction between the two forms was necessary.

I thus have introduced the name of *Orthis juniceps* for the form here under consideration.

III.—GROUP (OR SUB-DIVISION) OF *ORTHIS MICHELINI* (Lév.).5. *ORTHIS CORALLINA*, Waagen, n. sp.; Pl. LVI, fig. 1.

The general outline of this species is nearly circular, very little broader than it is long, with the ventral valve nearly flat and the dorsal one only very little curved.

The ventral valve is but very little curved in every direction, and even the apical region is not at all inflated. The beak is thin and pointed, barely at all incurved and very little projecting above the apex of the dorsal valve. The area is very small, and the hinge-line extremely short. The deltidial fissure is not distinctly visible, being for the greater part concealed by rock. The valve is smooth for the greater part, only in the frontal region a very faint impression takes place, causing the front-line to ascend a little.

The dorsal valve is very little smaller than the ventral one, but more strongly curved in every direction. The curve is rather flat in the longitudinal, and somewhat more strongly elevated in the transverse direction. The apex is little prominent, thin, pointed, and not much bent over. The valve is smooth for its whole extent, neither carinated nor impressed in the middle.

Both valves are extremely thick and heavy. They are covered by a fine radial striation, similar to that occurring in *Orthis michelini*.

The interior structure of this species is wholly unknown to me.

The measurements of the only existing specimen are as follow:—

Entire length of the shell . . . . .	25 mm.
Length of the dorsal valve . . . . .	24.5 "
Entire breadth of the shell . . . . .	26 "
Length of the hinge-line . . . . .	7 "
Entire thickness of the shell . . . . .	12 "
Apical angle of the ventral valve . . . . .	113°
" " " dorsal " . . . . .	130°

*Locality and geological position.*—The only specimen of this species that is known up to the present was collected by myself at Virgal in the coral-beds of the middle Productus-limestone.

*Remarks.*—On a first glance this species seems to be very similar to *Orthis michelini*, Lév., but on a closer examination one finds soon that only the group characters are identical, whilst the specific characters are decidedly different. The difference is chiefly striking in the general outline. This is always trapezoidal or more or less transversely oval in *Orthis michelini*, whilst the Indian form is nearly circular. This difference of outline is chiefly caused by the extreme shortness of the hinge-line and the nearly entire absence of an area in the ventral valve of *Orthis corallina*. Moreover, the Indian shell has extremely thick and heavy valves—a circumstance which is never the case, so far as I am aware, in *Orthis michelini*. Thus I think two forms can be well distinguished specifically.

Another form that must be compared to the present species is the one figured by Kayser from Lo-Ping in China under the name of *Orthis pecosii*, Marcou. This form is different from the Indian species by much more inflated valves and a much larger apical angle, which causes the shell to assume a more or less rectangular general outline. Thus also from this form the Indian shell can well be distinguished.

## 6. ORTHIS PECOSII, Marcou; Pl. LVI, fig. 13.

1858. *Orthis pecosii*, Marcou: Geology of North America, p. 48, pl. VI., figs. 14 a, b.

1858. *Orthis carbonaria*, Swallow: Transact. Acad. Scienc., St. Louis, I., p. 218.

1872. *Orthis carbonaria* (Swallow), Meek: Final report on Nebraska, p. 173, Pl. I. figs., 8 a, b, c.

The small specimen which serves for description belongs decidedly to the group of *O. michelini*.

The general outline is elongately roundish triangular, with strongly prominent not much unequal beaks and flattened valves.

The ventral valve is very little arched, but more so in the apical than in the frontal region, its curve being rather strong near the apex and very much flattened towards the front. Also in the transverse direction the curve is more strong in the middle and flattened towards the margins. The apex is well bent over and pointed, provided below with a very small area, which is, however, nearly all covered up by the apex of the other valve, as the ventral valve extends only little in excess of the dorsal one. The hinge-line is short, not projecting on both sides as has been erroneously drawn in the enlarged figure on Pl. LVI.

The dorsal valve is very little smaller than the ventral one, but it is more strongly inflated. Its curve is very strong in the apical region, but flattens all round towards the margins. The apex is strongly bent over, and concealed below the apex of the other valve. The hinge-line is very short, and the area of this valve cannot be seen at all.

Both valves are entirely smooth with the exception of some imbricating striæ of growth, and the fine radial striation characteristic of the species belonging to the group of *Orthis michelini*. The large perforations left by the removal of small tubular spines, which also occur on all these species, are, however, rather exceptionally numerous towards the margins of both valves in this species.

Of the interior characters of this species nothing is known to me.

The measurements of the only existing specimen are as follow:—

Entire length of the shell . . . . .	11 mm.
Length of the dorsal valve . . . . .	10 "
Entire breadth of the shell . . . . .	10.5 "
Length of the hinge-line . . . . .	4.5 "
Entire thickness of the shell . . . . .	5.5 "
Apical angle of the ventral valve . . . . .	91°
" " " dorsal " . . . . .	113°

*Locality and geological position.*—The only specimen of this species that has been found up to the present in the Salt-range was collected by myself at Aml in the so-called *Chonetes* bed of the lower division of the Productus-limestone.

*Remarks.*—I think there can be but little doubt that the specimen here described belongs to Marcou's species. The size as well as all the other characters are perfectly identical, and it would be rather difficult for me to indicate points of difference between the Indian and the American specimens.

In America, however, it seems that different things have been placed under the name; and especially the large form figured by Meek from California, I should not like to include in this species. So am I also doubtful whether the rather large and square specimen figured by Kayser from Lo-Ping in China can be assigned to Marcou's species.

*Orthis pecosii* is, in America, a characteristic species of the upper coal-measures.

#### 7. ORTHIS INCISIVA, Wägen, n. sp.; Pl. LVI., figs. 10, 11, 12.

The general outline of this species is elongately triangular with rounded corners. The valves are not much inflated and very little different in size, the dorsal one being smaller.

The ventral valve is slightly larger than the dorsal one and not at all inflated. Its curve is very unequal; longitudinally it is tolerably strongly vaulted in the apical region, but very soon the curve becomes flat, forming almost a plane down to the front-line. In the transverse direction the curve ascends rather rapidly from the margins of the valve, but is then suddenly strongly depressed. The remarkable flattening of the valve thus produced, without forming quite a sinus, is a very characteristic feature of the species. The apex is well bent over, pointed, and rather strongly prominent. The area is small, high, and strongly reclining, covered for the greater part by the apex of the other valve. The deltidial fissure cannot be observed. The front-line is entirely straight, or sometimes very slightly bent up towards the dorsal valve.

• The dorsal valve is a little smaller than the ventral one, but much more strongly inflated. Its curve is at the same time more regular. Longitudinally the curve is very strong in the apical region, and somewhat flattened towards the front. In the transverse direction the curve is equal throughout. The apex is very strongly bent over and partly disappears within the deltidial fissure of the other valve, in consequence of which the area of this dorsal valve is entirely concealed.

On both valves of this species some faint, slightly imbricating striae of growth are observable. The fine radial striation, characteristic of all these shells, is not very well preserved on all the specimens I have for description. The substance of both valves is comparatively very thick and heavy.

The interior characters of this species are entirely unknown to me.

The measurements of two specimens, one complete, the other only a ventral valve, are as follow:—

	I.	II.
Entire length of the shell . . . . .	9 mm.	15 mm.
Length of the dorsal valve . . . . .	8.5 „	...
Entire breadth of the shell . . . . .	8.5 „	13 „
Length of the hinge-line . . . . .	3 „	5 „
Entire thickness of the shell . . . . .	5.5 „	...
Thickness of the ventral valve . . . . .	2.5 „	4 „
„ „ „ dorsal „ . . . . .	3 „	...
Height of the area of the ventral valve . . . . .	1.5 „	2 „
Apical angle of the ventral valve . . . . .	75°	77°
„ „ „ dorsal „ . . . . .	100°	...

The specimen No. II is the largest that has been observed up to the present, and I doubt whether the species ever grew much larger.

*Locality and geological position.*—There have altogether five specimens of this species been found up to the present. All five were collected by myself near Amb in the lowest beds of the compact limestones which form the middle division of the Productus-limestone.

*Remarks.*—The general outline of this species is so very remarkable that its form cannot easily be mistaken. Of all the species of *Orthis*, this one has the smallest apical angle and the most strongly triangular shape. Nevertheless I think it cannot be doubted that the species forms part of the group of *Orthis michelini*. The very little inflated valves, the very approximated beaks of the valves, the short hinge-line, characters among the most striking of the group, this species possesses in common with *Orthis michelini*.

The species scarcely needs a closer comparison with any other form except with *Orthis peccosii*, Marcou. This American form also has a somewhat triangular outline and very little inflated valves; the beaks are very much approximated and tolerably prominent, but in all these characters *Orthis incisiva* is much more extreme than the American species, and besides this the peculiar flattening of the ventral valve is a character which does not occur in *Orthis peccosii*.

#### Family: STROPHOMENIDÆ.

In this family we find for the first time the type of the *Aphaneropegmata* fully developed. As has been stated above, *Orthis* and its allies are still provided with rudimentary crura in the dorsal valve, and might perhaps, together with the family *Rhynchonellidæ*, form a proper distinct sub-order, from which the others have taken their origin. In the *Strophomenidæ*, on the contrary, even rudiments of crura are entirely absent, and the most striking characters can only be derived from the different development of the cardinal process of the dorsal valve,—an organ that is of the greatest importance for the systematic arrangement of these shells. Nevertheless, this organ does not seem to replace the loop and crura of other Brachiopods

the parts to which the brachial appendages were fixed must be looked for elsewhere. Most recently Prof. Neumayr has published a short notice, in which he demonstrates the occurrence of reniform impressions also in *Strophomena*, and expresses the opinion that these reniform ridges were the organs to which the labial appendages had been fixed. We shall have occasion to recur to this opinion in describing the *Productidæ*, where reniform impressions are of far more general occurrence than in the *Strophomenidæ*.

The *Strophomenidæ* may be very conveniently divided into four sub-families, which can chiefly be distinguished by the different development of the cardinal process.

The first sub-family that I am able to distinguish is the ORTHISINÆ, to which only one genus, ORTHISINA, Orb. (*Hemipronites*, *Klitambonites*, &c., Pander), belongs. This genus is still very nearly related to *Orthis*; the cardinal process is very small, but every indication of crura, even only rudimentary, is absent. It forms by itself a very easily distinguishable group of the *Strophomenidæ*.

The second sub-family will have to bear the name of ORTHOTHETINÆ, and will comprise four genera, all provided with a strong cardinal process, which is mostly supported by two septa partly surrounding the muscular impressions. These genera are:—

1. TRIPLESIA, Hall, 1859 (12th Reg. Rep., New York State Cab., p. 44, figs. 1—3), Davidson: Suppl. Brit. Sil. Brach., p. 111. The strange bifid cardinal process shows very clearly that this shell belongs to the *Orthothetinaæ*, and not to the *Rhynchonellidæ* in which it has been placed by others.

2. STREPTORHYNCHUS, King, 1850: Monogr. Brit. Perm. Foss., p. 109. The cardinal process is large, supported by two septa, which partly surround the muscular impressions. The ventral valve is devoid of a median septum; permian.

3. DERBYIA, Waagen, n. gen. The cardinal process is very similar to that of the preceding genus, but in the ventral valve a strong median septum is present; carboniferous to permian.

4. MEEKELLA, White and St. John, 1856: Transact. Chicago Acad. Sci. I, p. 120, figs. 4—6. The cardinal process is similar to that in the preceding genera. In the ventral valve the hinge-teeth are supported by strong dental plates, which form two septa. A median ventral septum is absent; mountain-limestone (*Meek. olivieriana*, Verh.) to coal-measures (*Meek. eximia*, Eichw.; *Meek. striato-costata*, Cox).

5. ORTHOTHETES, Fischer von Waldheim, 1830: Oryctogr. du Gouv. de Moscou, p. 133, Pl. XX, fig. 4. Cardinal process small and not supported by septa, a little developed median dorsal septum mostly present; the ventral valve without a septum; devonian to (?) permian.

The third sub-family will bear the name of STROPHOMENINÆ. The forms belonging to this sub-family have the cardinal process mostly very small and always bifid, and the two valves leave very little space between them. The genera which I consider as belonging to this sub-family are the following:—

1. STROPHOMENA, Blainville, 1825, emend. Davidson.

2. STROPHODONTA, Hall, 1850: Proc. Am. Assoc., 1850, p. 348.

3. *LEPTAGONIA*, M'Coy, 1844: Synops. Carb. Foss. Ireland, p. 116, emend. Zittel: Handb. 678.

4. *LEPTÆNA*, Dalman, 1828, emend. Davidson.

It is not necessary to add here any particulars about these genera, as they are mostly already well known from Davidson's admirable works.

There remains, however, one group which probably forms part of the family *Strophomenidæ*; it is typified by the genus *Amphiclina*, Laube, which probably must be considered as the prototype of a fourth sub-family, for which I shall introduce the name of *AMPHICLININÆ*. To this sub-family the genus *Aulacorhynchus*, Dittmar, will probably also be assigned.

Of these four sub-families the first is of an exclusively silurian and devonian distribution. The second commences already in the silurian period and extends thence up into permian beds, perhaps even to still more recent formations. The third is also most numerous represented in the silurian and devonian epochs, and ascends only in isolated forms into carboniferous strata. The fourth at last occurs in carboniferous and triassic beds.

In the Salt-range only the *Orthothetinae* and the *Strophomeninae* are represented. Of the *Orthothetinae* three of the genera included by me in the sub-family occur in the Salt-range, and there are of the genus *Streptorhynchus* seven and of the genus *Derbyia* six species present; the genus *Orthothetes* has furnished only a single species. It then appears that the sub-family is altogether represented by fourteen species. Of the sub-family *Strophomeninae* there has up to the present been detected only a single somewhat doubtful species of *Leptæna*. It is a fact worthy of notice that the genus *Leptagonia*, which is of not rare occurrence in the carboniferous deposits of England and elsewhere, is entirely absent in the Salt-range.

Sub-family: *ORTHOTHETINÆ*, W.

Genus: *STREPTORHYNCHUS*, King.

It has given me very great trouble to find out what name this genus ought to bear, and even now I am somewhat in doubt on the matter, as still the possibility remains of its being identical with *Hipparionix*, but the true *Hipparionix* seems to possess dental plates, which are decidedly absent in *Streptorhynchus*. I have therefore returned to King's name *Streptorhynchus*, of which the signification is quite certain.

If we take the characters of the typical species, *Strept. pelargonatus*, to be those of the genus, we find that in the ventral valve the more or less high area is interrupted in the middle by a strong pseudodeltidium, which is always entirely closed. The hinge-line is generally not quite so long as the greatest breadth of the shell. On both sides of the termination of the pseudodeltidium tolerably strong hinge-teeth are situated, which are prolonged inside the area in prominent ridges



that accompany the pseudodeltidium. Any kind of septum in the ventral valve is entirely absent.

In the dorsal valve a large cardinal process is present, which is erect and reaches far into the cavity of the ventral valve. The process is bifid, bearing on its upper (dorsal) side a longitudinally in-cut line. On both sides of the process the dental sockets are placed and supported by short diverging septa, which partly surround the muscular impressions. In the dorsal valve the two pairs of adductor scars cannot well be distinguished, as they are not distinctly separated from each other, only between the right and left groups of impressions a distinct rounded ridge extends. In the ventral valve the muscular scars make also two groups of elongately oval impressions, separated from each other by a low rounded ridge; but also here the distinction of the scars of the cardinal and adductor muscles is difficult.

The characters by which this genus may most easily be distinguished are—the presence of two diverging septa in the dorsal valve and the absence of a median longitudinal septum in the ventral valve.

This genus is rather largely represented in the Salt-range, and there can be distinguished two large groups of forms, of which one has smooth and the other radially plicated valves. The first section I shall call "*Simplices*," and the second "*Plicati*." The second group exhibits a very great resemblance to the genus *Meekella*, White and St. John, and in fact I am very doubtful whether this genus ought not for the most part to be merged in the genus *Streptorhynchus*. Meek in the "Final report on Nebraska" gives a woodcut of *Meekella striatocostata*, in which he draws two strong septa, representing the dental plates, in the ventral valve. These septa certainly exist in some forms, but with them in Nebraska there also occur shells which are devoid of septa, as I have seen a specimen in the Royal Palæontological Museum in Munich in which these septa seem to be absent. Thus also in America the *Plicati* forms of the genus *Streptorhynchus* seem to occur, and this shows clearly that the plication alone cannot serve for the distinction of the genus *Meekella*. The absence of septa in the Indian shells has been pointed out already by Meek.

The first section, the *Simplices*, is represented in the Salt-range by four species, which can be separated into two groups. The first of these is typified by *Strept. pelargonatus*, Schloth., and is represented in the Salt-range by *Strept. pelargonatus*, Schl., and *Strept. lenticularis*, W. The second group comprises only forms that are restricted to the Salt-range. It will be called group of *Strept. capuloides*, W., and will contain the species *Strept. capuloides*, W., and *Strept. operculatus*, W.

The second section, the *Plicati*, is represented in the Salt-range by three species, which can again be brought into two groups, the first of which will have to bear the name of a group of *Strept. hallianus*, Derb., with only one species, *Strept. deltoidens*, W., and the second group will be called the "group of *Strept. pectiniformis*, Dav.," with two species, *Strept. pectiniformis*, Dav., and *Strept. distortus*, W.

We have thus arrived at the following grouping of the species :—

I.—Section SIMPLICES.

a.—Group of STREPT. PELARGONATUS, Schloth.

1.—*Strept. pelargonatus*, Schl.

2.— „ *lenticularis*, W.

b.—Group of STREPT. CAPULOIDES, W.

3.—*Strept. capuloides*, W.

4.— „ *operculatus*, W.

II.—Section PLICATI.

c.—Group of STREPT. HALLIANUS, Derby.

5.—*Strept. deltoideus*, W.

d.—Group of STREPT. PECTINIFORMIS, Dav.

6.—*Strept. pectiniformis*, Dav.

7.— „ *distortus*, W.

The genus seems in Europe to be restricted to the permian period, though perhaps some forms that occur in the mountain-limestone might also belong to it.

In the Salt-range the different species are distributed through the whole mass of the Productus-limestone, from the lowest to the topmost beds. The first section, the *Simplices*, is restricted to the lower and middle divisions, whilst the second section, the *Plicati*, chiefly occurs in the upper division.

Of all the seven species occurring in the Salt-range only one is identical with a European species; this is, *Strept. pelargonatus*, the well-known typical permian form. It is the typical form that occurs in the Salt-range, and not the one that has been called by Möller *Strept. pelargonatus*, and which belongs to the genus *Derbyia*. The occurrence of this form in India is of importance, as it again augments by one the number of permian species that are represented in the Salt-range.

I.—SECTION: SIMPLICES.

a.—GROUP OF *STREPTORHYNCHUS PELARGONATUS*, Schloth.

1. *STREPTORHYNCHUS PELARGONATUS*, Schloth. sp.; Pl. L, figs. 3, 4, 5, 7.

1816. *Terebratulites pelargonatus*, Schlotheim · Denkschr. d. K. Acad. d. W. in München, Vol. VI, p. 28, Pl. VIII, figs. 21—24.

1837. *Orthis laspi*, Buch.: Über Delthyris, p. 62.

1848. *Orthis pelargonata* (Schl.), Geinitz: Deutsch. Zechst., p. 13, Pl. 5, figs. 11—15.

1850. *Streptorhynchus pelargonatus* (Schloth., sp.), King · Monogr. Perm. Foss., 108, Pl. X, figs. 18—28.

1858. *Streptorhynchus pelargonatus* (Schloth. sp.), Davidson · Monogr. Brit. Perm. Brach., p. 32, Pl. II, figs. 32—42.

1861. *Orthis pelargonata* (Schloth. sp.), Geinitz: Dyas, Vol. I, p. 92, Pl. XVI, figs. 26—31.

1871. *Orthis pelargonata* (Schloth.), Quenstedt: Petref. Deutschl., Brachiop., p. 548, Pl. 55, figs. 51—56.

1880. *Streptorhynchus pelargonatus* (Schloth. sp.), Davidson: Suppl. Brit. Perm. Brach., p. 243, Pl. XXX, fig. 3.

The most instructive figures of this well-known species have been published by Geinitz and Davidson, and with these figures the Indian specimens agree in every detail.

This species never attains any considerable dimensions; and this is not caused, as might be supposed, by the supposition that it always forms part of a generally dwarfed fauna, for also in India it occurs always in small specimens, though it has lived there associated with truly gigantic shells, such as *Derbyia grandis*, which will be described later on in this work.

The general outline is extremely variable, and it is barely possible to give any positive general description of it. The ventral valve bears always a very large area, in consequence of which this valve is considerably larger than the dorsal one. The latter has always a slight median impression. The hinge-line is always shorter than the greatest breadth of the shell.

The ventral valve is generally longer than it is wide; only rarely is the contrary the case. The beak is not much pointed and barely at all bent over, but is twisted in various directions. The area is very large, vertical or somewhat reclining, provided in the middle with a not very broad vaulted pseudodeltidium. The depth and curvature of the valve are again very variable, but generally the ventral valve is deeper than the dorsal one. Sometimes the ventral valve bears an obtuse longitudinal median carination, sometimes not; but the frontal line always bends down to the ventral side, the ventral valve being indented by the dorsal one.

The dorsal valve is always considerably broader than it is long. It is always somewhat flattened, its curvature being never very considerable; it is, however, more strongly bent in the longitudinal than in the transverse direction. In the middle of this valve there is always a more or less strongly developed median impression which causes the front-line to descend considerably towards the ventral side. The area of this valve is mostly linear, and the apex but very little prominent.

Of the internal characters of this species nothing can be stated from the Indian specimens except the absence of a median septum in the ventral valve.

Both valves are covered by a fine radial striation, which augments towards the margins of the valves by intercalation of new ribs. This radial striation is crossed by strong imbricating striae of growth.

The measurements of two specimens from Katta are as follow:—

	I.	II.
Entire length of the shell . . . . .	20 mm.	15 mm.
Length of the dorsal valve . . . . .	13 „	11 „
Entire breadth of the valve . . . . .	13.5 „	13 „
Length of the hinge-line . . . . .	11 „	9 „
Thickness of both valves . . . . .	12 „	8 „
Apical angle of the ventral valve . . . . .	65°	75°

*Locality and geological position.*—This species is not very rare in certain beds at certain localities of the Salt-range. The greatest number (3 specimens) I collected

at Katta in the lowest beds of the compact limestones forming the middle division of the Productus-limestone (bed No. 13 of my note-book) within a few minutes during a rapid visit to the locality. Another specimen I found at Amb in the coaly sandstones forming the lowest fossiliferous beds of the Productus-limestone above the lavender-clays.

*Remarks.*—There cannot, it seems, be the slightest doubt that the Indian specimens represent the typical form, which was called originally by Schlotheim *Terebratulites pelargonatus*, and which is so very characteristic of the Zechstein and the magnesian-limestone of Europe. It needs only a comparison of the drawings published by Geinitz, chiefly the specimens represented in figs. 26 and 31 of Pl. XVI. of his work, to make the identity of those forms with the ones drawn on our Pl. L immediately apparent.

Something quite different from the Indian shells are, however, those fossils which have been called by Moller *Strept. pelargonatus*, and which were originally described by Abich under the names of *Strept. peregrinus* and *Strept. crenistria*, from permian beds of Armenia. We shall see later on that these form part of the genus *Derbyia*.

The occurrence of the typical form of *Strept. pelargonatus* in the Salt-range is of the greatest geological importance, as this form augments again by one the already considerable number of permian species occurring there.

## 2. STREPTORHYNCHUS LENTICULARIS, Waagen, n. sp.; Pl. L, fig. 8.

This is also a small species, which is characterised by its transversely oval outline, its small strongly reclining area in the ventral valve, and the general lenticular shape of the whole shell.

The ventral valve is flat, conical, not much vaulted in any direction. The curvature is, however, not quite regular; it is very slight in the longitudinal direction, and much stronger transversely, a barely perceptible broad obtuse ridge extending from the apex to the front, on both sides of which the valve is somewhat flattened. The apex is well pointed, prominent but not at all bent over; the area comparatively not very large, flat and rather strongly reclining, in the middle interrupted by a narrow convex pseudodeltidium. The hinge-line is very short.

The dorsal valve is considerably shorter than the ventral one. It is tolerably strongly inflated in the apical region, but otherwise it is rather flat. Its curvature is stronger in the longitudinal than in the transverse direction. The apex is slightly prominent and well bent over, the area only linear. From the apex down to the front there extends a broad but rather flat median sinus, which causes the front-line to descend in the direction of the ventral valve, and thus the dorsal valve indents the ventral one.

Both valves are covered by a fine but sharp radial striation which augments towards the margins of the valves by intercalation of new ribs. Besides this striation there are strong imbricating striæ of growth.

The internal characters of this species are not known to me.

The measurements of the only existing specimen are as follow :—

Entire length of the shell	. . . . .	20	mm.
Length of the dorsal valve	. . . . .	18	„
Entire breadth of the shell	. . . . .	21.5	„
Length of the hinge-line	. . . . .	12	„
Entire thickness of the shell	. . . . .	12	„
Apical angle of the ventral valve	. . . . .	98°	

*Locality and geological position.*—The only specimen of this species that has been detected up to the present was found by myself at Katta, in the lowest beds of the compact limestones that form the middle division of the *Productus*-limestone (bed No. 12 of my note-book).

*Remarks.*—This species is very nearly related to *Strept. pelargonatus* with which it occurs in the same bed, and many authors would probably not have separated it from that species. I think, however, that the much more regular general configuration of the whole shell, the smaller and more strongly reclining area and the marked lenticular shape, may serve for a specific distinction. So much is certain, that the form here under consideration does not present the features of the typical *Strept. pelargonatus*, and already for this reason it seems desirable not to mix up this form with the typical one.

The species here under consideration seems to be much rarer than the typical *Strept. pelargonatus*.

#### b.—GROUP OF *STREPTORHYNCHUS CAPULOIDES*, W.

##### 3. *STREPTORHYNCHUS CAPULOIDES*, Waagen, n. sp.; Pl. L, fig. 9.

Shell small, nearly globular, with strongly inflated valves, the ventral valve being slightly shorter than the dorsal one. The hinge-line shorter than the greatest breadth of the shell.

The ventral valve is depressed, conical, patelliform, the area being so large and so strongly reclining that the apex is shifted towards the centre of the valve. The curvature is very strong in the transverse direction, but barely perceptible longitudinally. The apex is pointed and not at all bent over; the area entirely flat, forming an equilateral triangle. In the middle of it extends a very narrow, vaulted pseudodeltidium, which bears a slight longitudinal impression on the top. The whole valve is regularly vaulted without any crest or median fold, though the front-line is slightly indented. Only along the crests that mark off the area there extend slight impressions from the apex to the terminations of the hinge-line, so that this line at both ends projects in little wings.

The dorsal valve is slightly larger than the ventral one. It is strongly inflated, chiefly in the apical region, but its curve is rather equal in both directions.

The apex is not prominent, but strongly bent over. There exists a very narrow but distinct area in this valve, which is not quite one millimeter broad, and

extends all along the hinge-line. In the middle it seems to be interrupted for the passage of the cardinal process. About half way from the apex there commences a broad but very shallow median sinus, which extends down to the front and slightly indents the ventral valve. Both ends of the hinge-line are slightly prominent, forming small indistinct wings.

Both valves are covered by a fine radial striation, but the concentric striæ of growth are not conspicuous.

Of the internal characters of this species nothing is known to me, except that a ventral median septum is absent.

The measurements of the only existing specimen are as follow :—

Entire length of the shell . . . . .	16.5 mm.
Length of the dorsal valve . . . . .	15 ..
Entire breadth of the shell . . . . .	18 ..
Length of the hinge-line . . . . .	11 ..
Entire thickness of the shell . . . . .	14 ..
Height of the area in the ventral valve . . . . .	9 ..
Apical angle of the ventral valve . . . . .	70°

*Locality and geological position.*—There is only a single specimen of this species known up to the present. It was collected by myself at Nursing-Pohár in black coaly calcareous beds, at the base of the limestones forming the middle division of the Productus-limestone, together with *Dielasma itailubense*, Derb., &c.

*Remarks.*—The general configuration of this species is very peculiar, and not at all similar to that of other species of *Streptorhynchus*, and I was for a long time inclined to consider it as belonging to the genus *Orthisina*. There is, however, not a trace of a foramen to be detected in the ventral valve, and the species also shows a certain typical similarity to *Strept. pelargonatus* as well as to the species which will be described next; and from these indications I have decided to place the species in the genus *Streptorhynchus*, though the internal characters of it are not known.

From *Strept. pelargonatus* the species is easily distinguishable by its inflated valves and by the shortness of the ventral one, caused by the large and extremely reclining flat area.

Of other species none can be compared more particularly to the present one.

#### 4. STREPTORHYNCHUS OPERCULATUS, Waagen, n. sp.; Pl. L, fig. 6.

This is again a very small species, of a semi-conical general form, the ventral valve being pyramidal or conical, and the dorsal valve resting on the other like an operculum. From this configuration, the shell assumes very much the appearance of a small *Caprina*, the similarity being augmented by the fine radial striation with which both valves are covered.

The ventral valve, as has been already stated, is elevated conical, with one vertical and one sloping side. The vertical side is occupied by the large area. The apex of this valve is not quite complete in the specimen that serves for description; it seems to have been not pointed but rather rounded, and not at all bent over. The area is very high, just as high as it is wide, forming an isosceles triangle, of which the hinge-line represents the short side; it is flat and concave and bears in the middle a narrow vaulted pseudodeltidium, which extends from the apex to the hinge-line. Except the area, the valve is very regularly rounded, and bears neither a median fold nor a median sinus. The front-line is nearly straight, only very lightly indenting this valve.

The dorsal valve is strongly inflated, chiefly in the apical region. Its curve is equally strong in both directions, but longitudinally the bend is stronger in the apical than in the frontal region. The hinge-line is very short, the area not quite linear, though very narrow. The apex is strongly bent over, but not prominent. There is only a slight trace of a median sinus observable; it commences at a short distance from the apex, and extends down to the front.

The surfaces of both valves are covered by a radial striation which is finer than in other species of *Streptorhynchus*. It is very similar to that occurring in many species of *Orthis*, but this apparent fineness of the striation may be partly due to the mode of preservation of this species, the surface of both valves being much corroded and otherwise obliterated by weathering.

The internal structure of this species is not known to me. The only point I could ascertain with certainty was the absence of a median septum in the ventral valve.

The measurements of the only existing specimen are as follow:—

Length of the dorsal valve	. . . . .	15 mm.
"    "    " ventral "	. . . . .	15.5 "
Entire breadth of the shell	. . . . .	15.5 "
Length of the hinge-line	. . . . .	8.5 "
Entire thickness of the shell	. . . . .	16 "
Height of the area of the ventral valve	. . . . .	8.5 "
Apical angle of the ventral valve	. . . . .	70°

• *Locality and geological position.*—The only specimen that has been detected up to the present was found by Dr. Oldham in the Bazárwán, in the middle Productus-limestone.

*Remarks.*—This species is so peculiar in its general configuration that it cannot easily be mistaken for any other forms. It is related to a certain extent to the species described before, but it is more extreme in its development in every respect. The ventral valve is still more elevated, and the dorsal median sinus is almost entirely absent. These peculiarities seem to be sufficient to distinguish between the two species; both might, however, be in developmental connection.

Of other forms none needs to be more particularly compared.

## II.—SECTION: PPLICATI

C.—GROUP OF *STREPTORHYNCHUS HALLIANUS*, Derby.5. *STREPTORHYNCHUS DELTOIDENS*, Waagen, n. sp.

The materials upon which this species is to be founded are rather scanty, only ventral valves in tolerably complete condition being known to me; but the outline of these valves is so peculiar that by them alone most decidedly a separate species is indicated.

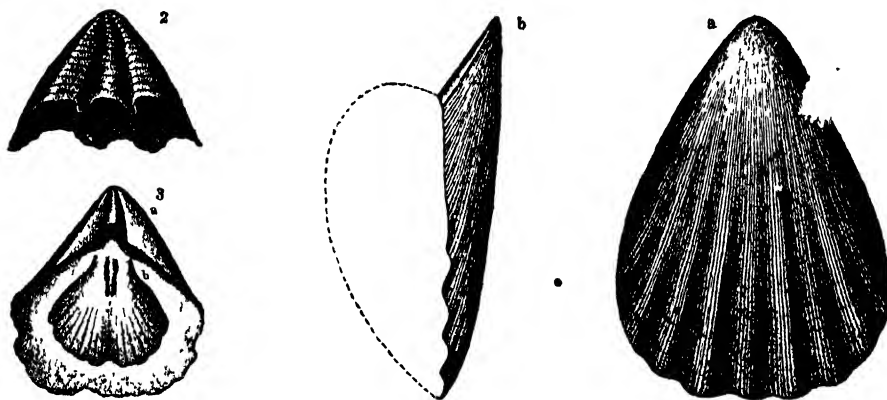


Fig. 15. *STREPTORHYNCHUS DELTOIDENS*, Waagen, n. sp. Fig. 1, ventral valve of a specimen from the middle Productus-limestone of Khura; 1a, ventral view; 1b, lateral view, both natural size. Figure 2, area and dental ridges of a specimen from the middle Productus-limestone of Khund. Figure 3, ventral view of a partial internal cast from the same bed and locality as the preceding; a, shelly mass filling up the apex of the valve; b, muscular impressions on the cast.

The general outline is elongately triangular, much longer than it is broad, with a nearly quite flat ventral and a strongly inflated dorsal valve. Both valves are plicated, but only near the margins. The species is of a middle size.

The ventral valve is nearly quite flat, and in the longitudinal, as well as in the transverse direction, its bend is very small. In the latter direction, however, it is somewhat more considerable than longitudinally, and the lateral parts especially bend rather abruptly down and even inwards to the hinge-line and the lateral shell-margins. The apex of the valve is very strongly prominent, pointed and not at all bent, quite straight, sometimes slightly twisted to one or the other side. The area is large, very high, but not so very broad, somewhat reclining and interrupted in the middle by a large, vaulted pseudodeltidium. The hinge-line is extremely short. There is no median fold or sinus to be observed in this valve, and the front-line is, excepting the undulations caused by the radial folds, quite straight. The radial folds are very irregular, highest at the margin of the valve, and commencing about half way from the apex. Their number is also very variable.

The interior characters of this valve are well preserved and can be most distinctly made out. They are very similar to those occurring in *Strept. hallianus* as they have been figured by Derby. The short hinge-line is interrupted on both sides of the pseudodeltidium by very strong and prominent hinge-teeth, which are



continued inside the area as prominent ridges up to the apex of the valve. A median septum is altogether absent. The large muscular impressions begin with their upper margins at the same distance from the apex as the termination of the area. The adductor or oclusor impressions are small elongated narrow scars situated in the middle at the upper end of the excavated space. The divaricator impressions, on the contrary, are large and fan-shaped, separated from each other by a slightly raised line and occupying nearly the whole excavated space.

The substance of the shell is for the most part extremely thickened in the apical region in this species, so that often the whole apex down to the hinge-line consists of one compact shelly piece.

The dorsal valve is very imperfectly known to me, as the only specimen in which the dorsal valve is preserved is so firmly impacted in the rock that it is impossible to expose it. Only in making a section through this specimen I learnt that the dorsal valve was strongly inflated and that it possessed a very strong cardinal process.

In one specimen from Khura it is possible to take some of the measurements; they are as follow:—

Entire length of the shell . . . . .	52 mm.
Length of the dorsal valve, about . . . . .	43 "
Entire breadth of the shell . . . . .	39 "
Length of the hinge-line, about . . . . .	17 "
Entire thickness of the shell . . . . .	25 "
Apical angle of the ventral valve . . . . .	72°

The apical angle of other specimens is larger, up to 92°.

*Locality and geological position.*—There are altogether seven specimens of this species known to me, which are all, however, in rather a fragmentary condition. Six of them were collected by Mr. Wynne at Khund, with silicified shell in a yellowish saccharoid limestone, forming beyond doubt part of the lower region of the middle Productus-limestone. All these specimens are ventral valves only. The seventh specimen I found myself at Khura in a white saccharoid limestone low down in the lower region of the middle Productus-limestone. This specimen is entire, but the dorsal valve is entirely covered by the firmly adhering very hard rock, and could not be cleaned.

*Remarks.*—The general outline of this species is very peculiar, and thus the species can well be recognised and will not easily be mistaken for any other form. The only species with which it can be more particularly compared is *Streptorhynchus hallianns*, Derby, from the coal-measures of Itaituba in Brazil. Both forms are identical, in the large valve being flat and the small one strongly inflated, in the rudimentary radial plication, and in the arrangement of the muscular impressions in the ventral valve; and thus there can at least be no doubt that they compose one group of very closely related forms. The two species can, however, easily be distinguished by the strangely triangular shape of the Indian shell, which is not to be found in the American species.

Of Indian species only *Strept. pectiniformis*, Dav., which will be described next, can be compared with the shell here under consideration. Davidson's species is, however, distinct, by the much more strongly inflated ventral valve, by the more strongly plicated shell leaving a distinct sinus in the dorsal valve, and by its much thinner shell-substance.

It might be possible that *Strept. deltoideus* is the ancestor of *Strept. pectiniformis*, but I am not sure on the point, and it appears to me that there exists a more close affinity between *Strept. hallianus* and *Strept. deltoideus* than between the latter species and *Strept. pectiniformis*, and according to this opinion I have also grouped the species.

#### d.—GROUP OF *STREPTORHYNCHUS PECTINIFORMIS*, Dav.

##### 6. *STREPTORHYNCHUS PECTINIFORMIS*, Davidson ; Pl. LV, figs. 4—11.

1862. *Streptorhynchus pectiniformis*, Davidson . Quart. Jour. Geol. Soc., Lond., Vol. XVIII, p. 30, Pl. I, fig. 17.

1863. *Streptorhynchus pectiniformis* (Dav.), Koninek . Fossiles paleoz. de l'Inde, p. 37, Pl. X, fig. 17.

The species is of a medium size, with inflated valves, a little longer than it is wide, and with many irregular radial folds, which commence only at a certain but very variable distance from the apex. The dorsal valve bears always a more or less strongly excavated median sinus.

The ventral valve is strongly inflated, showing an about equal curving in the longitudinal as in the transverse direction. Of median fold not a trace can be observed. The apex is strongly pointed, but always twisted to one or the other side. It is only slightly bent over. The area is large, always considerably broader than it is high, slightly concave, and interrupted in the middle by a narrow convex pseudodeltidium. The hinge-line is straight and comparatively long, projecting considerably but irregularly on both sides, by which are produced small wings projecting on both extremities of the hinge-line and marked off from the remainder of the shell by a furrow, which extends from the apex down to the end of the hinge-line. The valve is covered with a coarse radial striation only for a length of 15 or 20 millimeters from the apex ; coarse plications then begin to appear, which are at first very irregular, and only lower down become more and more regular and equal. The radial striation extends also on these plications, but is very unequal on different specimens. The striation mostly converges irregularly towards the top of the plications, as has been described by Meek in *Meekella striatocostata*, Cox. In other specimens, on the contrary, the striation remains approximately parallel, and only occasionally a convergence at the top of the plications can be observed. The number of plications is very irregular, but in full-grown, well-developed specimens mostly between nine and fifteen folds are present. Young specimens have often much less. The front-line is regularly rounded, slightly depressed in the middle. It presents a zig-zag line from the radial plications.

The dorsal valve is slightly more strongly inflated than the ventral one. Its curve is very regular in both directions, and it is not more strongly inflated in the apical region than elsewhere. A median sinus is always present, but very differently developed in different specimens. It is always very distinctly present in young specimens, beginning very near the apex, but mostly rather narrow. In adult specimens it becomes sometimes deeper and more strongly developed, but sometimes also it becomes less distinct and disappears almost entirely. The consequence is that the front-line in some specimens is strongly depressed in the middle, whilst in others it is nearly straight. The apex of the dorsal valve is pointed but not prominent, lying in one plane with the linear area which extends along the hinge-line. On both sides of the apex distinct wings are developed which give to this valve very strikingly the appearance of a pectenoid shell. The radial striation in this valve is just like that of the other one. On the wings the striation runs parallel to the hinge-line.

Both valves are provided with very strongly imbricating striae of growth, forming very neat zig-zag lines, and below which the radial striation appears in diverging directions, so as to converge again towards the top of the radial plications. This gives the shell-margin a fringed appearance, as the imbricating striae of growth are chiefly heaped together near the margin in both valves.

The internal characters of this species could be very accurately ascertained with the exception of the muscular impressions, which are extremely faint in all the specimens I have for description.

In the ventral valve there are on both sides of the vaulted pseudodeltidium strong, pointed, prominent teeth, which are continued inside the area as prominent, but not very strongly projecting, ridges along the pseudodeltidium up to the apex of the valve. There is not a trace of any septa observable. The muscular impressions, as far as they can be made out, seem to be very similar to those that I have been able to describe in *Strept. deltoidens*, but they are not at all excavated in the present species.

The dorsal valve is provided with a strong cardinal process which projects at about right angles from the plane of the valve. Seen from the dorsal side,—that is, from the outer side of the isolated valve,—this process is slightly bent over the apex of the valve, and bears here in the middle an incision, as if it were pierced by a visceral foramen, which is, however, not the case. From this incision extends a deep groove all along the posterior or dorsal face of the process down to the extremity, which it divides into two by a deep notch. On the sides of the notch two deeply hollowed out elevated ridges extend, so that the extremity of the process is provided with four very acute points, and thus often appears exactly like the extremity of the cardinal process of *Strept. pelargonatus* as figured by Davidson, Pl. II, fig. 39 of the British Permian Brachiopoda.

Laterally there are joined to this median part of the cardinal process two broad wing-shaped shelly plates, which must be considered as continuations of the socket-plates. The dental sockets themselves are small and marked off by a prominent

ridge, which extends from near the apex of the valve to the extremity of the wing-shaped plates. These latter are on their lower side again supported by shelly lamellae, which extend down to the bottom of the valve and form two short diverging septa. On its lower or ventral side the whole process is entirely smooth.

The muscular impressions in the dorsal valve are also very indistinct. They seem to be large, and separated from each other in the middle by a rather broad smooth space.

The measurements of two specimens, No. I from the Cephalopoda-bed of Jabi, representing the average size of the species, and No. II from the middle Productus-limestone of Swás, a rather small specimen, are as follow :—

	I.	II.
Entire length of the shell . . . . .	33 mm.	28.5 mm.
Length of the dorsal valve . . . . .	26 "	19 "
Entire breadth of the shell . . . . .	32 "	22 "
Length of the hinge-line . . . . .	19 "	11.5 "
Entire thickness of both valves . . . . .	21 "	14 "
Apical angle of the ventral valve without the wings . . . . .	80'	74°
" " " dorsal valve " " " . . . . .	114°	112°

Sometimes, though rarely, the species grows very much larger. The largest specimen known to me I have figured in Pl. LV, fig. 6; it measures 55 mm. in length.

*Locality and geological position.*—This is a rather common species in the upper division of the Productus-limestone; it is much rarer in the middle division of the same formation. In the lower division it has not yet been detected.

Most common is the species in the Cephalopoda-bed of the upper Productus-limestone. It has been collected in this bed by me at Jabi (15 specimens) and at Chidru (11 specimens). In other beds of the upper division the species has been found at Chidru (8 sp.) by Dr. Oldham and Mr. Wynne, in the mountains east of Katwáhi (2 sp.) by myself, in the section near Khura (2 sp.) also by myself, and at Khund Ghât (3 sp.) by Mr. Wynne.

In the middle division (upper and middle region) of the Productus-limestone the species has been detected at Vurcha (3 sp.) by Mr. Wynne, at Khyrábád (1 sp.) by myself, at Khund (1 sp.) by Mr. Wynne, and at Swás (1 sp.) by Dr. Oldham. Trans-Indus the species has been found in these beds at Káfirkot (2 sp.) by myself, and at Kálábágh (2 sp.) by Mr. Wynne.

*Remarks.*—From all the species that occur in India this one is easily distinguishable by the strong radial plication it possesses. It is otherwise, however, with respect to *Meekella striatocostata*, Cox, which bears a strong superficial resemblance to the Indian shell. I have remarked already in the description of the genus *Streptorhynchus* that in one specimen of *Meekella striatocostata* I had for comparison I could not detect the dental plates developed in the form of large septa characteristic of genus *Meekella*. Thus it seems probable that also in America species of *Streptorhynchus* occur that are radially plicated and bear in general a very great

resemblance to the Indian *Strept. pectiniformis*, whilst they are at the same time generically distinct from *Meekella striatocostata*. Nevertheless I should not be prepared to admit a specific identity of these American specimens with the Indian shells, on account of the much finer radial striation and the general absence of a sinus in the dorsal valve.

Of other species *Meekella garnieri*, Bayan, from carboniferous beds of China ought to be compared. Of this species, however, it is not known whether it is really a *Meekella* or not, and it appears not improbable that it is a simple *Strept. pectiniformis*. On the whole a certain resemblance to *Strept. pectiniformis* certainly exists, but the only specimen upon which the species has been founded is so badly preserved that it appears impossible to arrive at a positive opinion as to the identity or the difference of the Indian and Chinese forms. If the identity could be proved it would be of interest, as showing with some probability that beds of the age of the Salt-range Productus-limestone exist also in China: *Strept. pectiniformis* being one of the most characteristic species of all the fauna of the Productus-limestone.

In the external form also *Meekella erimia*, Eichw., shows a great resemblance to the Indian *Streptorhynchus pectiniformis*, but not only does Verneuil figure two very strong septa in the ventral valve, but also Trautschold mentions the existence of them, and thus there remains no doubt that the Russian species belongs to the genus *Meekella* and not to *Streptorhynchus*.

## 7. STREPTORHYNCHUS DISTORTUS, Waagen, n. sp.; Pl. LV, figs. 12-13.

This is a rather small species, about of the size of *Strept. pelargonatus*, and also otherwise not dissimilar to that shell. Both valves are very much contorted, and thus the general outline is very irregular. Radial plications are present, but they are irregular and not very distinct.

The ventral valve is rather strongly inflated, but of such an irregular curve that it is impossible to give any particulars about it. The apex is pointed, inflated, prominent, and very strongly bent over. The area is very large, concave, and striated, parallel to the hinge-line, as well as vertically. The pseudodeltidium is very narrow, vaulted, and very much shifted to one side, extending from the apex to where the apex of the other valve is situated. The hinge-line is comparatively long, being not much shorter than the greatest breadth of the shell. It terminates on both sides in little wings, very much as occurs in the preceding species. The radial plications begin at a short distance from the apex, are very irregular, and about seven to nine in number. They do not run parallel to the radial striation, but are crossed by it in the most various manner. The front-line forms an irregular zig-zag, and is slightly depressed in the middle.

The dorsal valve is somewhat flatter and less inflated than the ventral one, but its curve is also very irregular. It bears a slight sinus or impression in the middle. The apex is not prominent, not inflated, and often shifted to one side. On

both sides of the apex little wings are developed, from which the valve acquires a more or less pectenoid or aviculoid appearance. The hinge-line is straight; there is no area. The radial plications begin at a short distance from the apex. They are about eight to ten in number, very irregular, and not very prominent. In this valve also they are not parallel to the radial striation.

The radial striation is very fine in this species, much finer than in *Streptorhynchus pectiniformis*.

The internal characters of this species are very insufficiently known to me, only so much is certain that there are no septa in the ventral valve.

The dimensions of a full grown specimen from Virgal are as follow:—

Entire length of the shell	. . . . .	18 mm.
Length of the dorsal valve	. . . . .	13 "
Entire breadth of the shell	. . . . .	15 "
Length of the hinge-line	. . . . .	11 "
Entire thickness of the shell	. . . . .	10 "
Apical angle of the ventral valve without the wings	. . . . .	80°
" " " dorsal " " " "	. . . . .	115°

*Locality and geological position.*—There is only one full-grown specimen of this species preserved in the Salt-range collection. This was found by myself at Virgal in the topmost bed of the upper Productus-limestone. Several specimens which are apparently the young of this species were brought by Mr. Wynne from Bilot, where they occur in a similar geological position as at Virgal.

*Remarks.*—The present species is in general very similar to *Strept. pectiniformis*, Dav., but can be distinguished from that form by the much finer radial striation, its strongly distorted general shape, large area, and strongly bent-over apex; also the radial plication is less distinct, but is developed at a much earlier period of the shell's growth. It is highly probable that the two species are in a developmental connection.

There is no other species to which *Strept. distortus* could be more particularly compared.

#### Genus: DERBYIA, Waagen, n. gen.

The existence of this genus was recognised by Prof. Hall so far back as 1874, according to a note contained in Mr. Derby's description of the carboniferous Brachiopoda of Itaituba, but neither Hall nor Derby have given a name to it. Thus nothing remains for me but to give a name to these forms, which I do by calling them *Derbyia* in honour of Mr. Derby, who first drew the attention to the fact that the shells generally considered as *Streptorhynchus* exhibited a widely differing internal structure.

The forms here under consideration can be characterised in the following manner. The general outward appearance is the same as in the shells belonging to the genus *Streptorhynchus*. Internally the dorsal valve bears an extremely large

and massive bifid cardinal process, laterally united to massive shelly plates, which form a kind of diverging septa and partly surround the muscular impressions. These latter are large and deep, but not separated from each other in the middle by a septum.

In the ventral valve a very strong median septum extends from the apex to about half the length of the valve. The hinge-teeth are continued inside the area as prominent ridges up to the apex, and there unite with the median septum. Sometimes, however, this union is not restricted to the apical region alone, where the prominent ridges into which the cardinal teeth are prolonged are changed into a kind of central plates, united to the septum for their whole extent, thus forming a little trigonal chamber under the vaulted pseudodeltidium.

This existence of a very strong median septum in the ventral valve distinguishes the present genus very neatly from *Streptorhynchus*; whilst this same character as well as the presence of diverging septa in the dorsal valve make it easy to distinguish the genus here under consideration from *Orthotheses*, Fisch., which will be described next.

At the time when Hall drew attention to the peculiarities exhibited by the forms here under consideration, there were only three species known which possessed these peculiarities; they were *Strept. crassus*, Meek and Heyden, *Strept. robustus*, Hall, and *Strept. senilis*, Phill. To these was added a new species by Derby under the name of *Strept. correanus*, Derb. But these four species already represent two different types, marking two different sections within the genus. One section is typified by *Derb. senilis* and the other old species, which all three have the cardinal teeth free and united to the septum only at the apex, the other section is typified by *Derb. correana*, in which species the cardinal teeth are supported by short dental plates which are for the whole extent united to the median septum forming a small triangular chamber under the pseudodeltidium.

The latter section I shall call the "*Camerati*," whilst the others I shall call the "*Septati*." The *Camerati* are not represented in the Salt-range, though they are not restricted to the single South-American species *Strept. correanus*, Derb., but have also very interesting representatives in the permian beds of Armenia, the *Derbyia ensarkos*, Abich. (*Strept. crenistria* var. *ensarkos* and var. *incurreus*, Abich.: Bergkalk v. Djulfa, p. 73), and *Derbyia peregrina*, Abich. Both these species have, for reasons which I cannot quite conceive, been united by Prof. Val. v. Möller to *Strept. pelargonatus*, Schloth., though Mr. Abich in the description very distinctly mentions the ventral septum and the dental plates. These features alone indicate already the great difference that exists between these Armenian forms and *Streptorhynchus pelargonatus*, not to speak of the enormous size and the radial plications of the Armenian species.

The second section, the *Septati*, is largely represented in the Salt-range. The species belonging to this section can be distributed into three groups. The first is the group of *Derbyia senilis*, Phill. That Phillips' *Spirifera senilis* belongs to our genus has been stated already by Mr. Derby, who not only observed the exist-

ence of a large median septum in the ventral valve of European specimens, but also figures a very large cardinal process with shelly supports, forming diverging septa. These observations can also be confirmed by myself, and thus there remains no doubt that Phillips' species forms part of the genus *Derbyia*. It is the prototype of a group of forms for which a more or less inflated apical region of the ventral valve is characteristic. The group is represented in the Salt-range by four species which will bear the respective names of *Derbyia grandis*, W., *Derb. regularis*, W., *Derb. altestriata*, W., and *Derb. plicatella*, W.

The second group is that of *Derbyia crassa*, Meek and Worthen. This group can be recognised by an extremely heavy shell, which chiefly in the ventral valve is enormously thickened. The typical species has been described by the above-named author from the coal-measures of the Upper Missouri, but it seems that species belonging to the same group occur already in somewhat older strata, as in the Mining Journal of St. Petersburg a shell has been figured by Möller from the mountain-limestone of the Ural under the name of *Streptorhynchus crenistria*, which with some probability might belong to the present group. In the Salt-range the group is represented only by a single species, which will receive the name of *Derbyia vercherei*, W.

The third group is typified by *Derbyia robusta* of Hall. The group is easily recognisable by the extremely large, straight and compressed apex of the ventral valve. In India this group is represented also by a single species, which has been identified by Davidson directly with *Orthis robusta*, Hall. To me, however, an absolute identity between the American and the Indian shells seems not to exist, and I should be rather inclined to consider the Indian form as a distinct species, for which I shall introduce the name of *Derbyia hemisphærica*, W.

The grouping of the Indian species can thus be made in the following manner:—

Section · Septati.

a. Group of *DERBYIA SENILIS*, Phill., sp.

1. *Derbyia grandis*, W.
2. „ *regularis*, W.
3. „ *altestriata*, W.
4. „ *plicatella*, W.

b. Group of *DERBYIA CRASSA*, Meek & Worthen.

5. *Derbyia vercherei*, W.

c. Group of *DERBYIA ROBUSTA*, Hall.

6. *Derbyia hemisphærica*, W.

As regards the geological distribution of this species, the first, *Derbyia grandis*, has been found up to the present in the upper and middle divisions of the Productus-limestone; *Derb. regularis* is restricted to the lower and middle divisions, while *Derb. altestriata* and *Derb. plicatella* occur exclusively in the upper division of the same formation. *Derb. vercherei* is extremely rare and has been found up



to the present only in the middle division and *Derb. hemisphaerica* in the upper division of the Productus-limestone.

A fact that has already occurred three times to our observation, and which cannot be passed in silence, is that in several groups of the forms more or less nearly related to *Streptorhynchus* the geologically younger species attain more or less distinctly radially plicated valves. This peculiarity we had occasion to observe in the genus *Streptorhynchus* itself, where the form occurring with or above *Strept. pelargonatus*, viz., *Strept. pectiniformis* and *distortus*, are strongly radially plicated. Quite the same occurs in the genus *Meckella*, the mountain-limestone species, *M. olivieriana*, Vern., being smooth, while the species from the coal-measures and the upper carboniferous-limestone, *M. striatocostata*, Cox, and *M. eximia*, Eichw., have a strong radial plication. Another instance is the section of the "*Camerati*," within the genus *Derbyia*, where the geologically oldest species, *Derb. correna*, *Derb.*, is not plicated; while the permian forms, *Derb. eusarkos*, Abich, and *Derb. peregrina*, Ab., are more or less distinctly radially plicated. Lastly, in the section "*Septati*" of the genus *Derbyia* a similar peculiarity prevails, though in a much less degree. The geologically older species like *Derb. senilis*, Phill., *Derb. grandis*, W., and *Derb. regularis*, W., are smooth, without a trace of a radial plication; *Derb. plicatella*, on the contrary, which occurs in the Cephalopoda-bed of Jabi, has tolerably strong traces of such a plication. It is now in many instances very highly probable that the plicated forms are the descendants of the smooth ones, but if this be the case it is at the same time very improbable that a character which occurs in absolutely the same manner over the whole world should have been caused by external influences as climate, food, &c.; there must have existed within these organisms an innate law, according to which they were forced to assume with the progress of time, sometimes sooner, sometimes later, a radially plicated shape under most widely different external circumstances.

#### SECTION: SEPTATI.

##### a.—GROUP OF *DERBYIA SENILIS*, Phill.

##### 1. *DERBYIA REGULARIS*, Waagen, n. sp.; Pl. LIII, figs. 1, 2, 4.

The general outline of this species is mostly very regularly transversely oval, with a straight hinge-line, which is always shorter than the greatest breadth of the shell, and a not very prominent broad apex to the ventral valve.

The ventral valve is generally slightly vaulted; sometimes, however, it is more or less flat, and rarely even a little concave. In the specimens with a somewhat vaulted ventral valve, which are by far the majority, the curve of this valve is very regular and about equal in both directions. The apex is, however, always more or less flattened and depressed, never pointed and prominent. The area is largely triangular, flat, and crossed by numerous imbricating striae of growth disposed

parallel to the hinge-line. In the middle there is a rather large vaulted pseudodeltidium, which bears a distinct longitudinal furrow. This furrow is of great importance, as it indicates the existence of a median septum inside the valve. A trace of this furrow seems visible in Davidson's drawing, Pl. XXVII, fig. 2*b*, of his Carboniferous Monograph, representing the area of the original specimen of *Derb. senilis*, Phill. The surface of the valve is ornamented with some rounded concentric waves and numerous little, far separated imbricating striae of growth. The margins of the valve are everywhere rounded, and even the corners in which the hinge-line terminates do not much project. The frontal line is nearly quite straight, only very little depressed in the middle.

The dorsal valve is much more strongly vaulted than the ventral one, and its curve is very regular and equal in both directions. The hinge-line is comparatively long and straight, and the valve is somewhat flattened towards both ends of this line, whereby a kind of flattened wing is formed on each side. There is an area developed in this valve, but it is very narrow, nearly linear. The apex is well bent over and not prominent. There is never a median sinus in this valve, though the front-line is slightly depressed in the middle. This valve also is ornamented with small numerous far distant imbricating striae of growth; they are, however, entirely absent from a large space round the apex which is a very striking character of this species. Concentric wrinkles or waves as in the other valve are only rarely developed in this one, and if they are present, they are very indistinct.

The radial striation is very fine in this species, 7 to 8 striae within the space of 5 millimeters. It is very regular and not interrupted by striae of growth for a space of about 30 mm. from the apex of each valve, and augments as the shell increases in size by intercalation of new ribs.

The internal characters of this species are not quite perfectly known to me. In the ventral valve the median septum seems not to be very strongly developed, and apparently reaches on the anterior (dorsal) side only to half the length of the pseudodeltidium. On the other side it reaches down much lower and occupies about a third of the entire length of the valve.

In the dorsal valve the cardinal process is almost completely known to me. I have worked it out in a specimen from Swás, and only the termination of the process has been broken in thus preparing it. The process proceeds straight up from the hinge-line, it being situated in the plane of the valve, an arrangement which is necessitated by the little inflation of the apex of the ventral valve. Considered from the dorsal side (Pl. LIII, fig. 4*a*) the process consists of two parts, which are separated from each other by a deep and narrow furrow hemmed in on both sides by prominent ridges having a furrow at top. The process projects far above the hinge-line, is rather massive, and terminates in two short rounded branches. On the ventral face (Pl. LIII, fig. 4*b*) a strong median septum rises up, where on the other side the median furrow commences. It bifurcates where the process divides, and each branch is ornamented with a branch of the septum up to the top. On both sides of the process the dental grooves are situated (Pl. LIII,

fig. 1c). The shelly plates forming these grooves are continued into diverging septa, which descend a good distance into the interior of the valve. Above the dental groove the septum is drawn out into a shelly lobe which recalls somewhat the crura of the *Rhynchonellidae* and might perhaps be the morphological representative of those organs.

I was not able to make out the muscular impressions of any of the valves.

The measurements of a large specimen from Vurcha are as follow :—

Entire length of the shell . . . . .	73 mm.
Length of the dorsal valve . . . . .	61 „
Entire breadth of the shell . . . . .	88 „
Length of the larger lobe . . . . .	66 „
Entire thickness of the shell . . . . .	36 „
Apical angle of the larger valve . . . . .	155

The species seems not to become larger than the specimen of which the measurements are here given.

*Locality and geological position.*—This species commences in the lower division of the Productus-limestone and extends up into the middle division of the same formation, where it also terminates. In the upper division it is replaced by a smaller form which will be described next.

In the lower division the species has been collected by myself at Amb in the coaly sandstones forming there the lowest fossiliferous beds above the lavender-clays (4 sp.).

In the middle division the greatest number were found by Mr. Wynne, at Vurcha, in a shaly bed between the limestones (11 sp.). Another specimen was collected also by Mr. Wynne at Chidru.

*Remarks.*—This species is very nearly related to *Derbyia senilis*, Phill., as well as to *Derbyia robusta*, Hall, and seems to keep about the middle between the two forms. From the first species the present one seems to differ by the smaller area and the less strongly inflated ventral valve, as well as by a considerably finer and more regular radial striation. The slightly raised vertically striated median part of the area which appears very distinctly in some specimens of *Derb. regularis* seems to be absent in *Derb. senilis*. These differences may be sufficient to distinguish the two forms. On the whole it is, however, extremely difficult to distinguish the several species within the genus *Derbyia*, as the forms are very variable, and seem to be linked together by more or less numerous transitional shapes. Nevertheless I think the distinction of species should not be given up altogether, for this reason, that the typical shapes are always prevalent and often by their occurrence in certain distinct beds are of great geological importance. As in several of the genera of the *Terebratulidae* so in this genus the production of hybrids seems to have occurred very frequently.

The distinction from *Derbyia robusta*, Hall, is not difficult if we compare typical specimens, as in these the ventral valve is more strongly vaulted, and the whole shell more lenticular in the Indian form. In other specimens, however, the ventral

valve becomes more flattened, and then the Indian shell may become very similar to *Derbyia robusta*, but also in those specimens a decidedly distinguishing character consists in the constantly shorter hinge-line of *Derbyia regularis*. While in *Derbyia robusta* the hinge-line is very nearly as long as the greatest breadth of the shell, it is always very considerably shorter in *Derbyia regularis*, and thus again the Indian species seems distinguishable from the American form.

### 1a. DERBYIA REGULARIS, W., var. MINOR.

There occurs in the upper division of the Productus-limestone a species of *Derbyia* which is in all respects very similar to *Derbyia regularis*, except that it never attains nearly the size of the typical form and exhibits always a concave ventral valve. I should have distinguished this form as a proper species, but that also among the typical *Derbyia regularis* specimens occur having a concave ventral valve. It is true that this form, which constantly remains smaller and bears a concave ventral valve, is entirely restricted to the upper Productus-limestone, and also on geological grounds the form might well bear a proper designation, but considering the general extreme variability of the shells belonging to this genus, it would not seem quite prudent to create, on the evidence before me, a quite distinct species of these smaller specimens.

The measurements of two specimens, No. I from Kufri and No. II from Katwáhi, are as follow :—

	I.	II.
Entire length of the shell . . . . .	57 mm.	50 mm.
Height of the area in the ventral valve . . . . .	11 „	11 „
Length of the dorsal valve . . . . .	19 „	18 „
Entire breadth of the shell . . . . .	68 „	63 „
Length of the hinge-line . . . . .	64 „	45 „
Entire thickness of both valves . . . . .	23 „	26 „
Apical angle of the ventral valve . . . . .	133°	141°

*Locality and geological position.*—The variety is not very rare at certain places in the upper division of the Productus-limestone. It has been collected by myself at Kufri (6 sp.) and by Mr. Wynne west of Katwáhi (1 sp.) and at Chidru (1 sp.).

### 2. DERBYIA GRANDIS, Waagen, n. sp.; Pl. LI, LII, figs. 1 & 3; LIII, figs. 3 & 5.

1862. *Streptorhynchus crenistria* (Phill.), Davidson: Quart. Journ. Geol. Soc. Lond., Vol. XVIII, p. 30.

The general outline of this species is very irregular, more or less semi-circular, the hinge-line being about as long as the greatest breadth of the shell; the valves are not very strongly inflated, and the apex and area tolerably large and prominent. Both valves are covered by very irregular more or less concentric wrinkles.

The ventral valve is not much vaulted, though it is rather thick and inflated. In the longitudinal direction it is barely arched at all, while transversely it is rather strongly curved chiefly towards the lateral margins, and in the middle it appears often more or less flattened. The apex is prominent but not pointed, sometimes

slightly bent over, sometimes not at all, always more or less twisted to one or the other side. The area is large, triangular, but forming a very irregular triangle, in which only the hinge-margin forms a straight line. The area is sometimes slightly concave, sometimes not, and mostly rather strongly reclining. In the middle it is interrupted by a comparatively very narrow pseudodeltidium, which is slightly vaulted and bears in the middle a very distinct longitudinal furrow. On both sides of the pseudodeltidium a slightly raised triangular platform is marked off, which sometimes bears a distinct vertical striation, while on the remainder of the area only parallel slightly imbricating striae of growth can be observed. The hinge-line is nearly as long as the greatest breadth of the shell, but does not cause the formation of distinct wings. The surface of the valve is covered with very irregular concentric wrinkles or waves, which mostly coincide with rather strongly imbricating striae of growth. The apex of this valve is often so much deformed that it appears as if the shell had been fixed to some foreign body during youth. As the apex is more deformed, so also is the remainder of the valve crumpled in all possible directions.

The dorsal valve is less strongly inflated than the ventral one, yet it is much more strongly curved in every direction. The apex is slightly prominent, sometimes much vaulted, and sometimes rather flattened, but from the apex down to the front-line the valve extends always in a rather bold curve. In the transverse direction the curve is somewhat less considerable, chiefly towards both ends of the hinge-line the valve appears considerably flattened and thus indistinct wings are formed, by which this valve is well characterised. All along the hinge-line a very sharply defined but very narrow area extends. Though a distinct median sinus from the apex down to the front cannot be observed, yet there exists a kind of a median depression, which is sometimes more, sometimes less developed, and though often interrupted by the concentric wrinkles, it always produces a more or less strong median depression of the front-line. The concentric wrinkles are as numerous but less strongly prominent than in the ventral valve.

The radial striation is tolerably fine, sharp, but not prominent. In all specimens it is locally very irregular, the separate striae running into one another, &c. This is caused by frequent injuries received during lifetime when the animal mended its shell as best it could. How serious such injuries must have been is shown in the specimen figured in Pl. LII, fig. 1a; on the left of the specimen is a large space where the shell had been broken and is now in the first stage of repair. It is remarkable that the specimens belonging to this particular species are subject to such frequent injuries; it must have been a favourite food of some large fish.

The internal characters of this species are not entirely known to me, as the muscular impressions of the dorsal valve could not be made out.

The internal characters of the ventral valve can be seen as well on the partial cast figured, Pl. LI, as on the internal cast of a small specimen that is represented in Pl. LIII, fig. 3. The hinge-teeth are situated on both sides of the pseudodeltidium, and are continued inside the area as prominent ridges up to the apex of the valve. Between these ridges a thin median septum extends, which is, however, not

sufficiently high to reach the lower margin of the pseudodeltidium and thus to fill the whole cavity of the beak. On the bottom of the valve this median septum reaches down for about one-third or somewhat more of the entire length of the valve. It then divides in two branches, which encircle the muscular impressions and terminate before they reach the apex of the valve. The muscular impressions themselves are large and multilobed. These large scars are evidently the impressions of the divaricators, whilst the adductors apparently have left long narrow impressions on both sides at the base of the septum.

In the dorsal valve the most conspicuous feature is the enormous cardinal process, which I had occasion to observe in several specimens. I have figured a tolerably complete specimen, Pl. LIII, fig. 5, from which it appears at a glance that this process is much more massive in the present species than in the preceding one. It does not rise straight up from the apex of the valve, but projects under a more or less obtuse angle from it, and is at the same time considerably curved, the convex side of the curve being on the ventral, the concave on the dorsal side of the process. The ventral side of the process is entirely smooth, and does not bear a prominent septum-like ridge as in the preceding species. On the dorsal side the process bears in the middle a very deep and rather broad furrow, which towards the end of the process divides it into two thick short prongs. On both sides of this median furrow ridges extend up to the end of the prongs, which are broadly furrowed on the top. Laterally the cardinal process is united to the socket-plates. The dental sockets are large and roundish, marked off by a spur which projects from the hinge-line. The socket plates are continued towards the interior of the shell as thick diverging septa. At the place where the socket-plates unite with the cardinal process a broad wing-shaped shelly projection is formed which is probably the morphological representative of the crura of *Rhynchonellidae*. The similarity is augmented by a prominent ridge, which originates not far from the apex, runs along above the dental sockets, and terminates with a gentle inward curve at the extremity of the shelly projections just described—a position which exactly corresponds to the position of the crura of a *Rhynchonella*. The exact form of the muscular impressions of this valve is not known to me.

The measurements of two specimens, No. 1 from Káfirkot, and No. II from Musakhayl, are as follow :—

	I.	II.
Entire length of the shell . . . . .	116 mm.	86 mm.
Length of the dorsal valve . . . . .	96 "	72 "
Entire breadth of the shell . . . . .	119 "	96 "
Length of the hinge-line . . . . .	102 "	86 "
Thickness of both valves . . . . .	49 "	39 "
Apical angle of the larger valve . . . . .	113°	? 136°

The specimen No. I is the largest that has been observed by me.

*Locality and geological position.*—This species occurs throughout the middle and upper divisions of the Productus-limestone, but in the upper division it becomes generally not quite so large as in the middle one.

In the middle Productus-limestone the species has been found by myself at Chidru (2 sp.), in the mountains east of Katwáhi (1 sp.), and at Káfirkot (1 sp.). Mr. Wynne brought the species from the Bazárwán (1 sp.), from north of Katwáhi (1 sp.), from Morah (1 sp.), from the Chittawán (1 sp.), from Khyráád (1 sp.), and from north of Káfirkot. An excellent specimen has been contributed by Dr. Warth from Musakhyl.

In the upper Productus-limestone the species has been obtained by Mr. Wynne at Khund Ghát (8 sp.), and by myself in the section at Kufri (2 sp.), and in the Cephalopoda-bed at Chidru (1 sp.).

*Remarks.*—This species is very nearly related to *Derbyia senilis*, Phill., with which in fact it has been identified by Mr. Davidson. The distinctive characters which are sufficient, according to my view, to distinguish the Indian form as a proper species, consist in a yet greater irregularity of growth, in a less prominent apex, a by far smaller area and longer hinge-line, and in a very considerably narrower pseudodeltidium in the Indian shells. Also the size is not nearly reached by European specimens. These characters might be sufficient for the distinction of the species, though by some people they may not be thought so; it cannot, however, be denied that the Indian shell does not exhibit the typical shape of the specimens of *Derb. senilis* occurring in the European mountain-limestone. Thus I think it is more prudent to give a new name to the Indian form than to quote it under the name of a species with which it does not entirely agree.

Also *Derb. regularis* is similar to a certain extent to the present species, but it can be much more easily distinguished by the more regular shape, the sporadic occurrence of a concave ventral valve, which never has been observed in *Derb. grandis*, and by its finer radial striation.

### 3. DERBYIA ALTESTRIATA, Waagen, n. gen. et sp.; Pl. LI, fig. 2.

This species is of a middle size, with a more or less semi-circular outline and approximately lenticular shape. The most striking character, however, consists in the extremely coarse and raised radial striation.

The ventral valve is rather flattened and but very little vaulted in both directions. The apex is pointed, but very little prominent. The area not very large and strongly reclining; it forms a tolerably regular, flat, horizontally striated triangle, in the middle of which a narrow vaulted pseudodeltidium is situated, which latter bears on the top an excavated line extending nearly down to the hinge-margin. The surface of the valve is covered with distant, very prominent concentric wrinkles which are tolerably regular, and give to this valve a characteristic appearance. The frontal margin is slightly cut out in the middle.

The dorsal valve is much more strongly inflated and vaulted than the ventral one; its curve is, however, about equal in the longitudinal direction as well as in the transverse one. The apex is slightly prominent, pointed, and strongly bent over. The area of this valve is narrow but very distinct. On both sides of the

apex, along the hinge-line, the valve is considerably flattened and spread out, forming indistinct wings. From the apex down to the front a shallow and not very broad but yet quite distinct sinus extends. This valve also bears a concentric sculpture, but in the opposite sense of that of the other valve—that is to say, there is a depression or furrow in this valve, where there is an elevated wrinkle or wave on the other one. The concentric imbricating striae of growth are much less conspicuous in this than in other species of *Derbyia*.

The most characteristic feature is the radial striation. It is coarser and the single ribs are more highly elevated than in any other species of *Derbyia*. I have seen up to the present their height reaching nearly one millimeter. At the same time the fine scaly concentric striation, which occurs in nearly all the *Orthothetina* is very distinct and coarse in this species. The radial striae augment but rarely by intercalation.

Of the internal structure of this species but very little is known to me, only the strong median septum of the ventral valve being visible in one of the specimens.

The measurements of the larger of the two existing specimens are as follow :—

Entire length of the shell	. . . . .	38 mm.
Length of the dorsal valve	. . . . .	36 "
Entire breadth of the shell	. . . . .	46 "
Length of the hinge-line	. . . . .	37 "
Entire thickness of both valves	. . . . .	20 "
Apical angle of the ventral valve	. . . . .	140°
" " " dorsal "	. . . . .	100°

*Locality and geological position.*—There are altogether only two specimens of this species preserved in the Salt-range collection. Both were found by myself at Jabi in the Cephalopoda-bed of the upper division of the Productus-limestone.

*Remarks.*—This species is more or less nearly related to all the species previously described. It can, however, be distinguished from all of them by the regular shape, the strong concentric wrinkles, which are prominent folds on the ventral and depressions on the dorsal valve, and by the much stronger and higher radial striation. These same characters are also sufficient to distinguish the present form from other species which have not been described in this work. Thus it can well be distinguished from *Derb. senilis*, Phill., and others, and so it forms, I consider, a sufficiently distinct and well-distinguishable species. •

#### 4. *DERBYIA PLICATELLA*, Waagen, n. gen. et sp.; Pl. IV, fig. 3.

This is a very rare middle-sized species, of an about lenticular shape, with not very inflated valves, and not very strongly developed radial plication.

The ventral valve is tolerably strongly vaulted, with an about equal curve in both directions. The apex is rather much inflated, pointed, and strongly bent over. The area is broad, high and strongly concave, provided with many imbricating striae of growth parallel to the hinge-line. The pseudodeltidium is large and not quite distinctly defined. The sculpture of this valve besides the radial striation consists for the greater part of irregular concentric wrinkles, which often appear as high concentric folds and are more or less in connection with strong imbricating striae of



growth. A short distance from the margins of the valve the concentric sculpture disappears more or less, and gives way to a radial one, which consists of very irregular not very high radial plications, giving to the margin of the valve more or less the form of a zig-zag line. The lateral parts of the shell margin are slightly depressed, while the median or frontal part is somewhat bent up, without, however, a distinct median fold being formed on this valve.

The dorsal valve is perhaps a little more strongly vaulted than the ventral one, and its curve is very regular in both directions. The apex is barely prominent, pointed, but not at all inflated, rather flattened. It is not bent over. The area is narrow but very distinct. Towards both ends of the hinge-line the valve is somewhat flattened and spread out, forming a kind of wings. The valve shows a concentric sculpturing, consisting of folds and depressions, but it is much less strongly developed in this than in the other valve. Not far from the margin also in this valve this sculpturing disappears to be replaced by a radial one. This latter consists of very irregular coarse radial folds, some of which begin earlier, some later, but which are all most strongly developed at the shell-margin itself. Also then the lateral distance from each other is very irregular. The front-line is depressed, but without the formation of a distinct median sinus.

The radial striation of both valves is rather fine, and the single striae are also rather low, just the contrary of what is the case in the preceding species.

Of the internal characters of this species only the very strong median septum in the ventral valve can be observed. The substance of the shell is very thin.

The measurements of the only existing specimen are as follow :—

Entire length of the shell	. . . . .	47 mm
Length of the dorsal valve	. . . . .	40 "
Entire breadth of the shell	. . . . .	52 "
Length of the hinge-line	. . . . .	38 "
Entire thickness of both valves	. . . . .	27 "
Apical angle of the ventral valve	. . . . .	131°

*Locality and geological position.*—This is a very rare species, and up to the present only a single specimen of it has been detected. This was found by myself at Jabi, in the Cephalopoda-bed of the upper Productus-limestone.

*Remarks.*—It is not difficult to distinguish this species from others of the same genus. The strongly concave area, the fine radial striation, and the radial folds by which its margin is ornamented, are characters which in the same combination are not to be found in any other species.

Of not Indian species none can be more particularly compared to the present one.

#### *b.*—GROUP OF *DERBYIA CRASSA*, Meek and Hayden.

##### 5. *DERBYIA VERCHEREI*, Waagen, n. gen. et sp.; Pl. LIV, fig. 1.

As all the species of this group so also the present one is characterised by an extremely heavy and ponderous shell, of an about trapezoidal outline.

The ventral valve, the only one known to me, is nearly quite flat, partly even slightly impressed, and only the extremely thickened shell-margin is again strongly bent up. The apex is but little prominent and not pointed, the area small, but very little reclining. It is quite flat, not in the slightest degree concave or vaulted. In the middle it is interrupted by a broad but short pseudodeltidium, which does not entirely fill up the deltidial fissure, but is largely cut out at its lower extremity, apparently to allow of the passage of a rather large pedicle. The pseudodeltidium is but very little vaulted, and bears in the middle a longitudinal impression, by which circumstance the presence of a median septum inside the valve is marked. On both sides of the pseudodeltidium a rather large slightly raised triangular platform is marked off, which bears a very distinct vertical striation. Otherwise the area is only sculptured by distant very strong imbricating striæ of growth, which extend parallel to the hinge-line. Along the hinge-line the enormously thickened shell-substance forms a flattened space, which apparently has been covered up by an equally thickened hinge-region of the dorsal valve. Near the hinge-teeth and outside of them, this flattened space bears narrow elongated grooves, which apparently served for the reception of a kind of hinge-teeth of the dorsal valve, with which apparently the present species has been provided. The external surface of the ventral valve is in its sculpture very much like that of other species of the same genus. It is provided with extremely strongly imbricating striæ of growth, which are nearly absent up to a distance of 35 mm. from the apex, after which up to 60 mm. some strong ones occur, when the shell-margin suddenly bends up, and countless scaly striæ of growth are heaped together. The front-line is straight, the hinge-line is much shorter than the greatest breadth of the shell, and this latter is situated nearer to the front than to the hinge-line.

The radial striation is not very fine nor sharp. It is crossed as in other species by neat concentric striæ, which give a somewhat scaly appearance to the radial striæ.

The internal characters are excellently visible on the specimen at my disposal. The hinge-teeth are continued inside the area as prominent ridges extending on both sides along the pseudodeltidium; but they are not so strongly developed as to form distinct septa which would extend down to the bottom of the valve and divide the interior of the beak longitudinally into different parts. The muscular impressions are very deep and very large, occupying half of the entire length of the valve. They are surrounded by a high undulating shelly crest, which flattens where it approaches the cardinal region, thus not uniting to the dental ridges. The whole space of these muscular impressions is divided longitudinally by a very high and sharp median septum, which commences at the apex and extends down to the end of the muscular impression. Towards the extremity of the beak, this septum reaches up from the bottom of the valve to the pseudodeltidium, and is grown together for a certain extent with it, but lower down the pseudodeltidium becomes again free. On both sides of this septum one should expect to find the impressions of the adductors, while the larger part of the whole impression would be due to

the divaricators. I am, however, quite unable to distinguish the adductor impressions, and I cannot say how the adductors may have been fixed.

The measurements of the only existing specimen are as follow:—

Entire length of the shell . . . . .	68 mm.
Height of the area . . . . .	11 "
Length of the median septum . . . . .	33 "
Entire breadth of the shell . . . . .	72 "
Length of the hinge-line . . . . .	52 "
Thickness of the valve at lower margin of area . . . . .	10 "
" " " at the frontal margin . . . . .	16 "
Apical angle . . . . .	140°

*Locality and geological position.*—The only specimen of this species that is known to me consists in a quite free ventral valve of enormous thickness which was found by Dr. Verchere at Bilot (trans-Indus). The bed from which the specimen came is not exactly known, but from its mode of preservation it appears very probable that it came from the middle division of the Productus-limestone.

*Remarks.*—It cannot be denied that the materials upon which this species is founded are barely sufficient for the purpose, but on the other hand the form can be so well and easily distinguished from all the other species of the genus occurring in the Salt-range, that on this ground alone it may be useful to distinguish it. At the same time it is of much interest that the Indian shell is so very nearly related to *Derbyia crassa*, Meek, and Hayden, of the American coal-measures.

From all the Indian species *Derbyia vercherei* can be distinguished by its regular outline, flat ventral valve, little prominent beak, and the enormously thickened shell-substance. By this latter character as well as by the largeness of the muscular impressions in the ventral valve, the species here under consideration approaches very closely the *Derbyia crassa*, from which it can be distinguished by its much larger size and the much more strongly developed median ventral septum.

Also in Europe very nearly related forms seem to occur; at least there has been figured by Möller a ventral valve from the upper carboniferous-limestone of the Ural, under the name of *Strophomena crenistria*, Phill., which is apparently very like the species I have here described under the name of *Derbyia vercherei*.

All these seem to constitute one group of forms which is easily distinguishable and well characterised by the extreme heaviness and solidity of the shell.

#### c.—GROUP OF *DERBYIA ROBUSTA*, Hall, sp.

##### 6. *DERBYIA HEMISPHERICA*, Waagen, n. gen. et sp.; Pl. LIV, figs. 1—3.

1862. *Streptorhynchus crenistria* (Phill.), var. *robusta* (Hall), Davidson: Quart. Journ. Geol. Soc., Lond., Vol. XVIII.

1863. *Streptorhynchus crenistria*, Phill., var. *robusta* (Hall—Davids.), Koninck: Fossiles de l'Inde, pag. 36, Pl. X, fig. 16.

*This species is always of a middle size, and never becomes so large as the preceding one. One valve is quite flat, the other very strongly inflated, and the*

beak is very strongly prominent and compressed. The whole shape of the shell is mostly quite regular.

The ventral valve is quite flat, very rarely slightly concave. Only towards both ends of the hinge-line the margins of the valve are slightly bent up. The hinge-line is always a good deal shorter than the greatest breadth of the shell. The area is extremely large, triangular, and more or less reclining. It is quite flat, and ornamented only by usually not well-marked imbricating striae of growth which extend parallel to the hinge-line. In the middle, on both sides of the pseudodeltidium, there is again a slightly raised space which mostly bears a faint vertical striation. The pseudodeltidium itself is narrow, very little vaulted, and bears a slight longitudinal impression in the middle. The surface of the valve is ornamented by distant, sometimes imbricating striae of growth. The margins are either all in one plane or the frontal margin appears slightly depressed.

The dorsal valve is very strongly inflated, more or less hemispherical. Its curvature is equal in both directions, and only towards both ends of the hinge-line it is slightly flattened, so that a kind of small wings is formed. These are sometimes less strongly developed, but never stronger than in the specimen figured by Davidson in the Quarterly Journal. The apex of this valve is not at all prominent and very strongly incurved. The area is distinctly developed, though very narrow. The surface of the valve is covered by distant, sometimes imbricating striae of growth.

The surface sculpturing consists in both valves of a fine radial striation, which is crossed by very fine, concentric, somewhat scaly striae of growth. There exists, however, at the same time in this species a great propensity to form a radial plication, but which never becomes very distinct. Traces of such a plication are visible on the specimen figured by me, Pl. LIV, fig. 2*b*. In other specimens this plication becomes yet stronger, and chiefly on the dorsal valve it can then be distinctly seen. The majority of specimens remain, however, smooth.

The internal characters are only very imperfectly known to me. The median septum in the ventral valve is very strongly developed, and divides the interior of the beak in two halves nearly down to the hinge-line. The hinge-teeth are strong and continued inside the area as prominent ridges up to the apex. The muscular impressions are large and deep. In the dorsal valve the cardinal process seems to be not very large. The dental sockets, however, are supported by shelly plates, which extend far inside the valve as prominent diverging septa. The muscular impressions of the dorsal valve are not known to me.

The measurements of two specimens from Khura are as follow :—

	I.	II.
Entire length of the shell . . . . .	50 mm.	54 mm.
Length of the dorsal valve . . . . .	40 "	43 "
Entire breadth of the shell . . . . .	51 "	54.5 "
Length of the hinge-line . . . . .	45 "	48 "
Entire thickness of the shell . . . . .	30 "	30 "
Apical angle of the ventral valve . . . . .	130°	130°

The species never becomes larger than the specimens of which the measurements are here given.

*Locality and geological position.*—The species is almost entirely restricted to the upper division of the Productus-limestone and has been found up to the present only in very sporadic specimens in the uppermost beds of the middle division.

In the Salt-range collections there is a single specimen from the limit between the upper and middle divisions of the Productus-limestone. This specimen was collected by Mr. Wynne, trans-Indus at Kálabágh.

All the other specimens are from the upper division. The species has been found in these beds at the following localities: At Khund Ghat (21 sp.) and at Nurpur (1 sp.) by Mr. Wynne; at the section near Khura (5 sp.) and west of the same village (3 sp.) as well as at Chidru (1 sp.) by myself. Dr. Warth brought the species from Musakhey (1 sp.), not from the bed with silicified fossils, but from a bed of sandstone in which the fossils are contained in a calcareous condition. There is but little doubt that this sandstone forms part of the upper division of the Productus-limestone.

*Remarks.*—This species has been identified by Mr. Davidson with *Orthis robusta* of Hall, and it cannot be denied that the similarity between the Indian and the American shells is very great. Nevertheless I should not be quite inclined to adopt Davidson's opinion. If within that group of forms which has up to the present generally been united under the name of *Streptorhynchus crenistria*, Phill., we once come to distinguish several different genera, according to the different internal structure that occurs in these shells, we are then also obliged to draw the limits of the different species somewhat more closely, and to consider forms as specifically different, which formerly would not have been so distinguished. In such a position are we also in this case; and though I believe that *Derb. robusta*, Hall, and *Derb. hemisphærica*, W., belong to one and the same group of forms, yet I think that the two shells must be considered as specifically different. The Indian shell can easily be distinguished from the American one by the always less considerable size, an outline in which length and breadth are nearly equal, and the by far more strongly developed beak.

But in Europe as well as in America there occur forms which are very similar to the present species. Among these chiefly *Streptorhynchus crenistria*, Phill., var. *cylindrica*, McCoy, must be mentioned. Of this form excellent figures have been given again by Mr. Davidson in his Supplement to the British Carboniferous Brachiopoda. From these figures it appears that the European form differs from the Indian one chiefly by the concave ventral valve. In the cast represented in fig. 7 by Davidson this concavity seems to be less developed, but this cast is otherwise very different and must be put into the genus *Meekella*. It could perhaps be compared to *Meekella olivieriana*, Vern.

Of other Indian species several must be compared. There is before all *Derbyia regularis*, var. *minor*, W., which in general appearance is rather similar to the

present species. It can be distinguished by its much smaller and less prominent beak and the flatter dorsal valve; also in its general outline it is often much less regular than *Derb. hemisphærica*.

*Derbyia vercherei*, W., which is also similar, can be well distinguished by its larger size, smaller beak, and the extreme thickness of its shell-substance.

Genus: ORTHOTHETES, Fischer v. Waldheim.

Though this name has been quoted as applied by Evans to certain forms already in the year 1829, yet the genus cannot be considered as fairly established before the year 1830, when in the first edition of the "Oryctographic" the interior of a dorsal valve was distinctly figured and the genus definitively transferred to the Brachiopoda by Fischer v. Waldheim. In the edition of 1830 only the interior of the dorsal valve was figured, whilst in the edition of 1837 an external view of a ventral valve is added.

In both cases there cannot remain the slightest doubt that the name was applied to a shell very nearly related to *Streptorhynchus crenistria*, Phill., and which chiefly in the internal characters of the dorsal valve is generically identical with Phillips' species. The name must thus be restricted to those forms and the genus may be characterised in the following manner:—

The external shape of the shells belonging to this genus is in no way characteristic, and it is only by the internal characters that the genus can be recognised.

In the dorsal valve a cardinal process of moderate dimensions exists, which is generally bifid and comparatively broad. Laterally it is joined to the walls of the dental sockets. These latter are not very large and not supported by shelly lamellæ, so that the diverging septa, which are characteristic of the preceding genera, are absent in the present one. Instead of these, however, there seems to be not rarely a median dorsal septum developed, which is immediately joined to and takes its origin at the cardinal process. This median dorsal septum appears on Fischer v. Waldheim's original figure as well as on Pl. XXVII, fig. 6, of Davidson's Carboniferous Monograph.

In the ventral valve, as far as my experience goes, every kind of septum is absent.

The muscular impressions of both valves have been excellently described by Mr. Davidson, but they are in their general arrangement very similar to the muscular impressions of other genera.

There can be no doubt that *Strept. crenistria*, Phill., belongs to this genus, even if it should be proved that Fischer v. Waldheim's original specimen did not belong to the same species. Also the species or varieties *St. radialis*, Phill., and *St. arachnoidea*, Phill., perhaps too the typical *St. cylindrica*, M'Coy, will have to be connected to it. Otherwise not much is known of species of the genus. There has been described a species belonging to this genus by Derby under the name of *Strept. tapajotensis*, from the coal-measures of Brazil, and of Devonian species are quoted also by Derby, *Strept. arctostriata*, Hall, *St. pandora*, Hall, and *St. agassizi*, Hartt.

Also *Strept. devonicus*, Orb., which has been placed by Derby in another group of forms, belongs, in my opinion, to this genus, as the diverging septa of the dorsal valve, characteristic of the preceding genera, are absent in it.

In the Salt-range the genus is represented by a single species, which will bear the name of *Orthothetes semiplanus*, W.; it occurs in the Cephalopoda-bed of the upper Productus-limestone.

It is impossible to tell whether this species is in a more or less close relation to the *Orthothetes crenistrata*, *Orthoth. radialis*, or any of the other species. As yet too little is known of these to attempt a definite grouping of the species.

#### 1. ORTHOTHETES SEMIPLANUS, Waagen, n. sp.; Pl. LV, figs. 1, 2.

This species is of rather small size, and of a characteristic transversely oval outline. Of the two valves, the larger one is depressed conical, the smaller quite flat. The hinge-line is slightly shorter than the greatest breadth of the shell.

The ventral valve is of a flatly conical shape, rather strongly vaulted in the transverse, and but little arched in the longitudinal direction. The area is very large, flat, triangular and strongly reclining. It is interrupted in the middle by a very large strongly vaulted pseudodeltidium. The apex is prominent, pointed, and bent over just at its extremity. The surface of the valve is smooth without a median fold or sinus. Besides the radial striation, which is very unequal in strength and resembles in this respect somewhat that of *Orthothetes radialis*, Phill., there are only some strong imbricating striæ of growth at very irregular distances. The margins are all in one plane and the frontal one is not at all or only very slightly indented. The dorsal valve is quite flat and not vaulted in any direction. Only in the middle it is slightly depressed, so that a kind of very flat and broad median sinus is formed. The apex is entirely flattened, neither prominent nor pointed. The hinge-line is straight, provided with a narrow but very distinct area. In the middle it is somewhat swollen where the cardinal process is fixed to it. The radial striation is less unequal in strength in this valve than in the other one. The concentric imbricating striæ of growth are also less strongly developed. The frontal margin is mostly slightly depressed.

Of the internal characters of this species but little is known to me, as the specimens were too few to allow of investigations in this direction. From an isolated dorsal valve from Chidru it is, however, possible to state that the cardinal process is short, bifid and rather broad, in shape very similar to that of *Orthothetes tapajotensis* as figured by Mr. Derby. Diverging septa are absent. The interior of the ventral valve is entirely unknown to me.

The measurements of a rather small specimen from Jabi are as follow:—

Entire length of the shell	. . . . .	21 mm.
Length of the dorsal valve	. . . . .	17 "
Entire breadth of the shell	. . . . .	25 "
Length of the hinge-line	. . . . .	22 "
Entire thickness of the shell	. . . . .	10 "
Apical angle of the ventral valve	. . . . .	113°

*Locality and geological position.*—There are altogether only two specimens of this species known to me, both from the Cephalopoda-bed of the upper Productus-limestone. They were collected by myself, a bi-valved one at Jabi, and the other, a dorsal valve only, at Chidru.

*Remarks.*—There can be, I think, but little doubt that the present species belongs to the genus *Orthothetes*, though the internal characters could not be entirely made out; but it is very difficult to ascertain what are the specific relations of this form. It appears in such an isolated manner in the Salt-range that from its geological position no conclusion can be drawn as to its relation to other forms, and one is restricted for such considerations to mere similarities.

A certain similarity exists between the present species and *Orth. crenistria*, Phill., but the semi-conical form of the ventral, and the entirely flat condition of the dorsal valve, are features which seem not to occur in Phillips' species, and thus the two forms will probably be different.

Other species are yet much less similar, and scarcely need a closer comparison, and thus the present species appears as a rather isolated form of uncertain affinities.

#### Sub-Family: STROPHOMENINÆ.

#### Genus: LEPTÆNA, Dahn. (emend. Davids.).

It is with great doubt and hesitation that I introduce this genus into the fauna of the Salt-range. The interior of the little shell which I place in this genus is absolutely unknown to me; and only the existence of a very distinct area in the smaller valve, and the typical similarity to other species of *Leptæna* like *Lept. oblonga* or *Lept. transversalis*, induce me to place this shell in that genus.

After the extremely interesting discovery of spirals in the interior of *Lept. liasina* by Mr. Munier Chalmas, I thought it indispensable for me to detect also spirals in the shell from the Salt-range, as this shell bears a great external resemblance to *Koninckella liasina*, but all my endeavours failed, and I must now believe that the Salt-range shell really possessed no spirals.

After this nothing remains for me but to place this shell either in the genus *Leptæna* or *Chonetes*, and I have put it into the first of these, on account of the development of distinct area in the smaller valve and the absence of spines along the margin of the area of the larger valve.

The only species in the Salt-range will bear the name *Leptæna indica*, Waagen. It occurs not very rarely at certain localities at the base of the compact limestones forming the middle division of the Productus-limestone.

#### 1. LEPTÆNA INDICA, Waagen, n. sp.; Pl. LVIII, figs. 7, 8, 9.

This little shell has either a circular, or a somewhat transversely or elongately oval shape. The ventral valve is strongly inflated and convex, the dorsal one as much concave. Both valves are entirely smooth.



The ventral valve is so strongly inflated that it appears nearly semi-globose in outline. It is equally vaulted in both directions, and the curve is not stronger near the apex than near the front. The apex is not very prominent, pointed, and strongly bent over. The hinge-line is long and straight, as long or longer than the greatest breadth of the shell. Thus distinct wings are produced of a triangular shape and slightly vaulted. All along the hinge-line a narrow but distinct area extends, which is highest in the middle. Below the apex this area is cut open by a comparatively small triangular slit, of which I am not able to indicate with certainty whether it is closed by a pseudodeltidium or not. The area is mostly more or less concave. The surface of the valve is entirely smooth, and even with the lens no sculpturing can be distinguished. If the smooth epidermis is taken off, a rather coarse punctation of the shell-substance appears.

The dorsal valve is concave and follows in its curvature in every respect the curvature of the ventral one. The wings are also distinctly developed and concave. There is no distinct apex of this valve. Along the hinge-line a distinct narrow area is developed, which bears in the middle a triangular prominence, where the cardinal process is inserted. This valve also is entirely smooth.

Of the interior characters of the species nothing is known to me.

The measurements of three specimens from Katta are as follow:—

Entire length of the shell	. . . . .	9 mm.	9 mm.	8 mm.
Entire breadth of the shell	. . . . .	10 "	9.5 "	7.5 "
Length of the hinge-line	. . . . .	10.5 "	10.5 "	7 "
Entire thickness of the shell	. . . . .	4.5 "	5 "	3.5 "
Distance of the valves from each other	. . . . .	2 "	2 "	1.5 "
Apical angle of the ventral valve	. . . . .	110°	100°	96°

No larger specimens of this species have been observed.

*Locality and geological position.*—This species is restricted to a single bed at the base of the compact limestones composing the middle division of the Productus-limestone. It has been collected in this position by myself at Katta (6 sp.) and at Nursing Pohár (1 sp.).

*Remarks.*—It has been remarked already in the exposition of the genus that the classing of this species with *Leptæna* is rather doubtful.

As to species the silurian *Leptæna oblonga* and *transversalis* are not dissimilar, but it is not quite probable that they should be specifically identical. Another form, however, the distinction of which is very difficult, is *Productus lævis*, Davids., from the carboniferous beds of the Kashmir valley. On a first glance at the drawing one would take the two forms to be absolutely identical, and I cannot at all assert whether they are not so in reality. Of the Kashmir form, however, the dorsal side is not known, and thus it cannot be ascertained whether an area is present or not. As Mr. Davidson has put this shell into the genus *Productus*, it is most certain that he could not state the presence of an area, and thus it must remain doubtful whether the Kashmir and the Salt-range shells are identical or not. In awaiting the solution of this question from new finds in Kashmir, I have introduced the above name for the Salt-range form in a provisional way.



## PLATE L.

### PRODUCTUS-LIMESTONE.

- Figures 1—2. *SPIRIFERINA ORNATA*, Waagen, n. sp., p. 505, Fig. 1. Complete specimens from the top beds of the upper Productus-limestone of Chidru; 1*a*, dorsal view; 1*b*, ventral view; 1*c*, lateral view; 1*d*, front view; 1*e*, portion of the shell-surface, enlarged. Fig. 2, dorsal valve only of a specimen from the same bed and locality as the preceding.
- 3—5 (& 7). *STREPTORHYNCHUS PELARGONATUS*, Schloth., sp., p. 579. Three specimens from the lowest beds of the middle Productus-limestone of Katta; all figures natural size, except figures 3*c* and 3*d* (the number of the latter figure has been inadvertently omitted on the plate), which are somewhat more than two times enlarged.
6. *STREPTORHYNCHUS OPERCULATUS*, Waagen, n. sp., p. 583. Specimen from the middle Productus-limestone of the Bazárwán; 6*a*, dorsal view; 6*b*, ventral view; 6*c*, lateral view; 6*d*, front view; all natural size.
- 7 (& 3—5). *STREPTORHYNCHUS PELARGONATUS*, Schloth., sp., p. 579. Specimen from the lowest fossiliferous beds above the lavender-clay of Amb; four views, natural size.
8. *STREPTORHYNCHUS LENTICULARIS*, Waagen, n. sp., p. 581. Specimen from the lowest beds of the middle Productus-limestone of Katta; four views, natural size.
9. *STREPTORHYNCHUS CAPULOIDES*, Waagen, n. sp., p. 582. Specimen from the lowest bed of the middle Productus-limestone of Nursingpohár: 9*a*, ventral view; 9*b*, dorsal view; 9*c*, front view (ventral valve below); all three figures natural size; 9*d*, ventral view; 9*e*, lateral view; 9*f*, view from the hinge-line (ventral valve above); the latter three figures enlarged.







PLATE LI.

PRODUCTUS-LIMESTONE.

Figure 1. *DIBBYIA GRANDIS* Waagen, n. gen. et sp., p. 597. Specimen from the middle Productus-limestone of Kafirkot. 1, ventral view, 1a, dorsal view, 1b, lateral view, 1c, view from the hinge-line, all natural size.





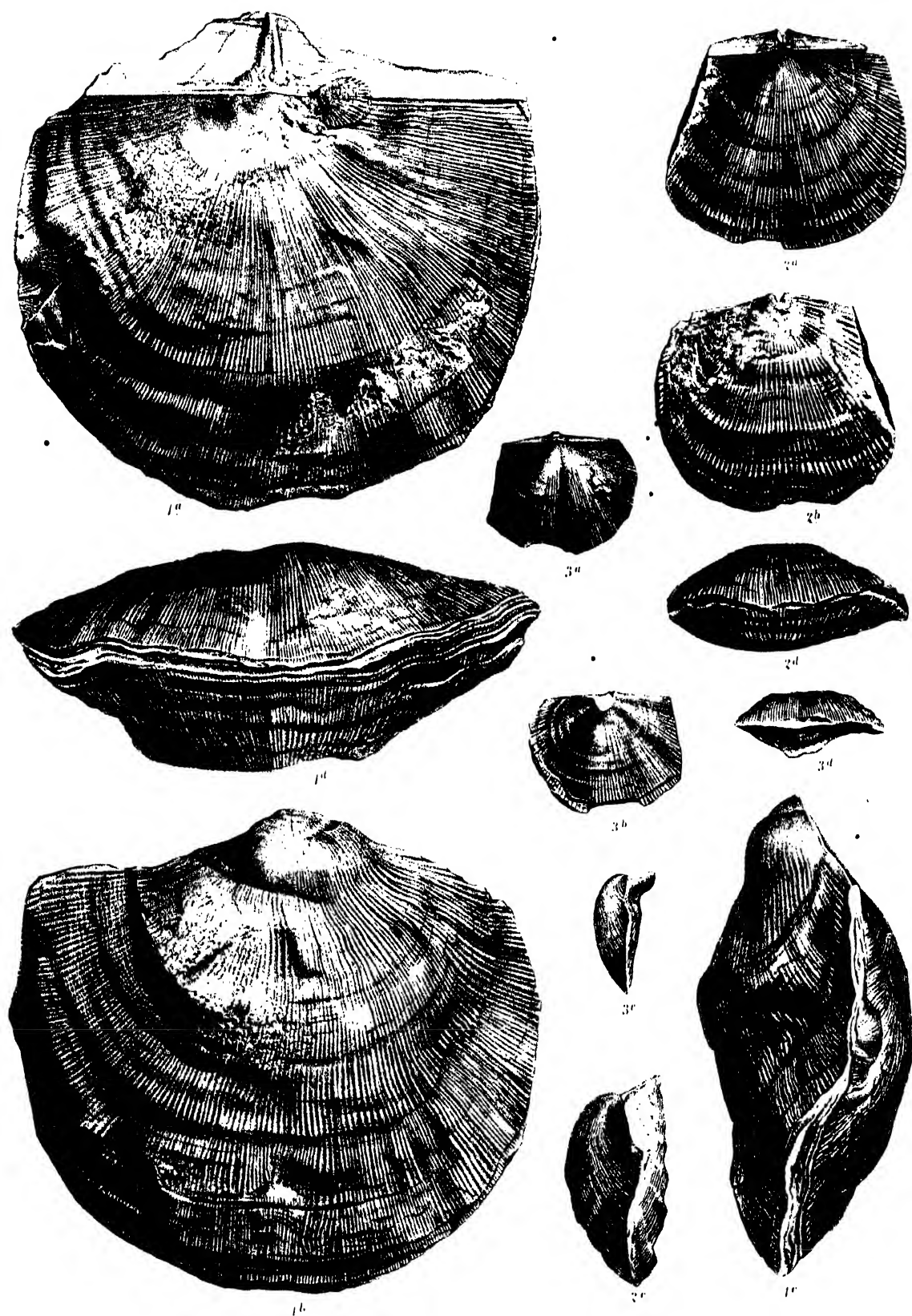




## PLATE LII.

### PRODUCTUS-LIMESTONE.

- Figures 1 (& 3). *DERBYIA GRANDIS*, Waagen, n. gen. et sp., p. 597. Specimen from the upper region of the middle Productus-limestone of Musakhey1; 1*a*, dorsal view; 1*b*, ventral view; 1*c*, lateral view; 1*d*, front view, the ventral valve below; all natural size.
2. *DERBYIA ALTESTIMATA*, Waagen, n. gen. et sp., p. 600. Specimen from the Cephalopoda-bed of the upper Productus-limestone of Jabi; 2*a*, dorsal view; 2*b*, ventral view; 2*c*, lateral view, 2*d*, front view, the ventral valve below; all natural size.
- 3 (& 1). *DERBYIA GRANDIS*, Waagen, n. gen. et sp., p. 597. Young specimen from the upper Productus-limestone of Khund Ghát: 3*a*, dorsal view; 3*b*, ventral view; 3*c*, lateral view; 3*d*, front view; all natural size.







## PLATE LIII.

### PRODUCTUS-LIMESTONE.

- Figures 1—2 (& 4). *DERBYIA REGULARIS*, Waagen, n. gen. et sp., p. 594. Two specimens from the middle Productus-limestone of Vurcha : 1, a young specimen : 1*a*, ventral view ; 1*b*, dorsal view ; 1*c*, lateral view ; 1*d*, front view : 2, a full-grown specimen ; 2*a*, dorsal view ; 2*b*, ventral view ; 2*c*, lateral view ; 2*d*, front view, the ventral valve below.
- 3 (& 5). *DERBYIA GRANDIS*, Waagen, n. gen. et sp., p. 597. Artificial internal cast of the ventral valve of a specimen from the upper Productus-limestone of Vurcha.
- 4 (& 1—2). *DERBYIA REGULARIS*, Waagen, n. gen. et sp., p. 594. Cardinal portion of the dorsal valve of a specimen from the middle Productus-limestone of Swás, the cardinal process slightly broken at the extremity ; 4*a*, external view ; 4*b*, internal view ; 4*c*, view from above.
- 5 (& 3). *DERBYIA GRANDIS*, Waagen, n. gen. et sp., p. 597. Cardinal portion of the dorsal valve of a specimen from the middle Productus-limestone of Bilot ; 5*a*, external view ; 5*b*, internal view ; 5*c*, view from above ; 5*d*, lateral view.

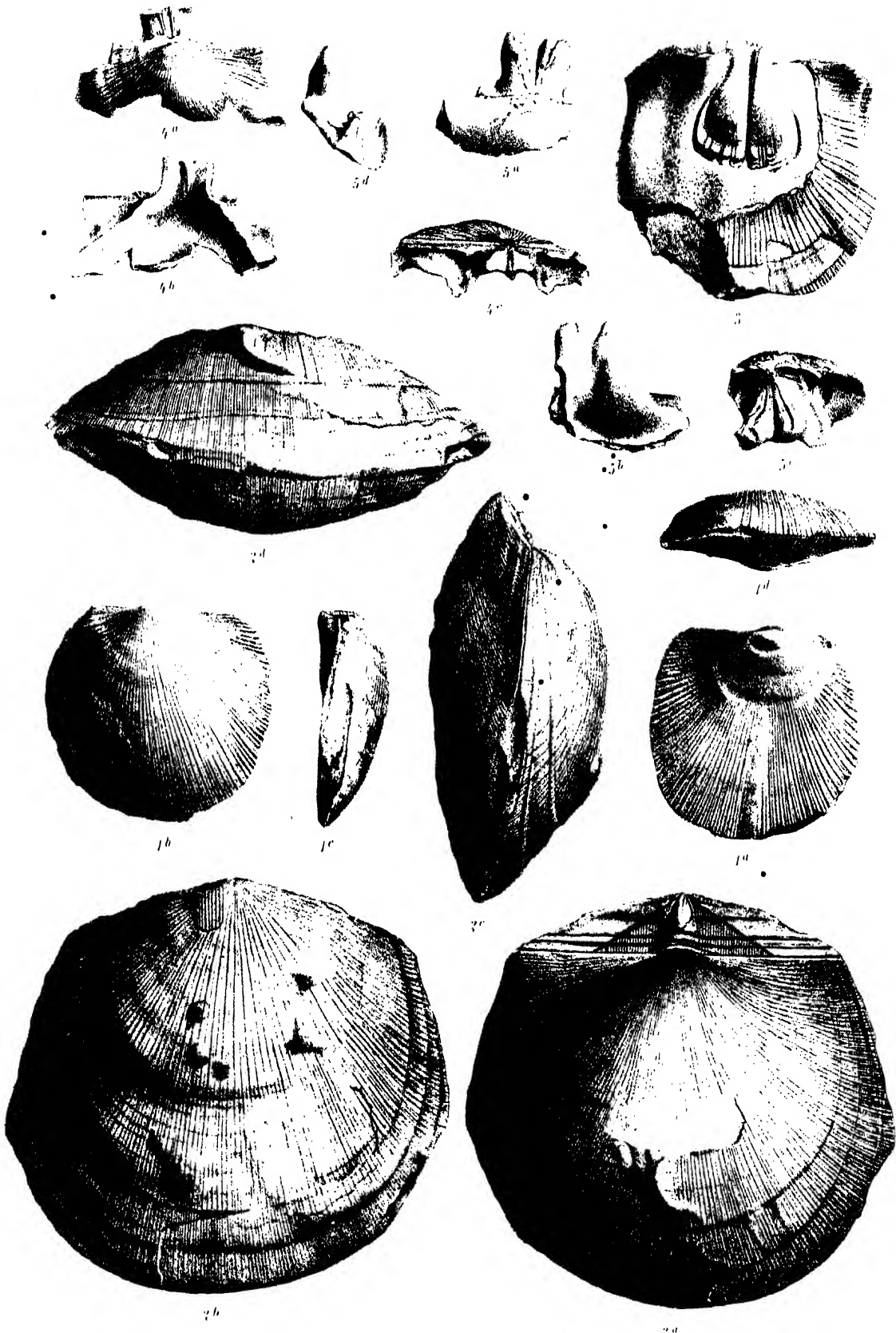




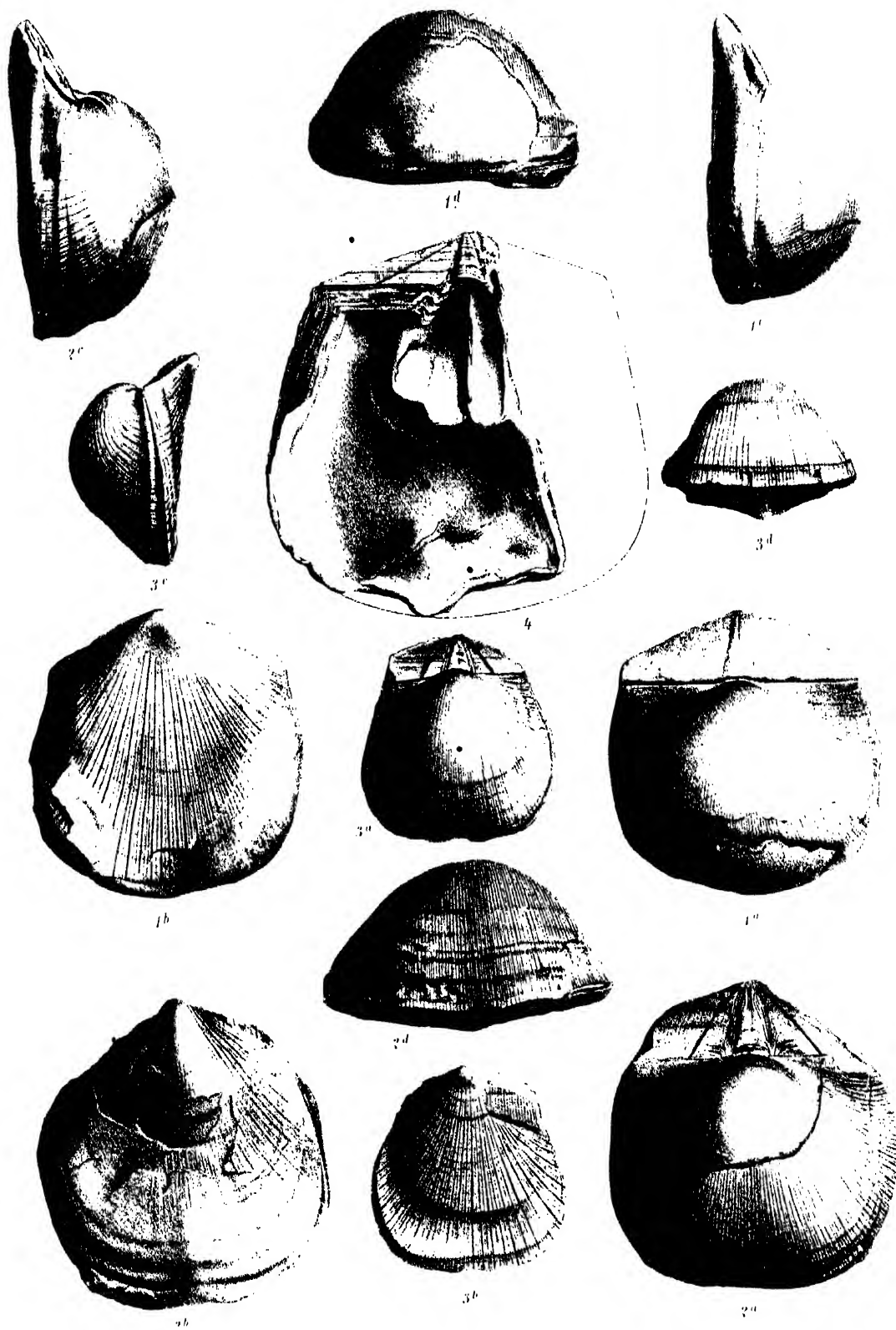




PLATE LIV.

PRODUCTUS-LIMESTONE.

- Figures 1—3 *DERBYIA HEMISPHERICA*, Waagen, n. gen. et sp., p. 604. Figs. 1 & 2, two specimens from the upper Productus-limestone of the section near Khura ; fig. 3, young specimen from the upper Productus-limestone of Musakhey1 ; *a*, dorsal view ; *b*, ventral view ; *c*, lateral view ; *d*, front view, the ventral valve below.
4. *DERBYIA VERCHEREI*, Waagen, n. gen. et sp., p. 602. Internal view of an isolated ventral valve from the middle Productus-limestone of Bilot.



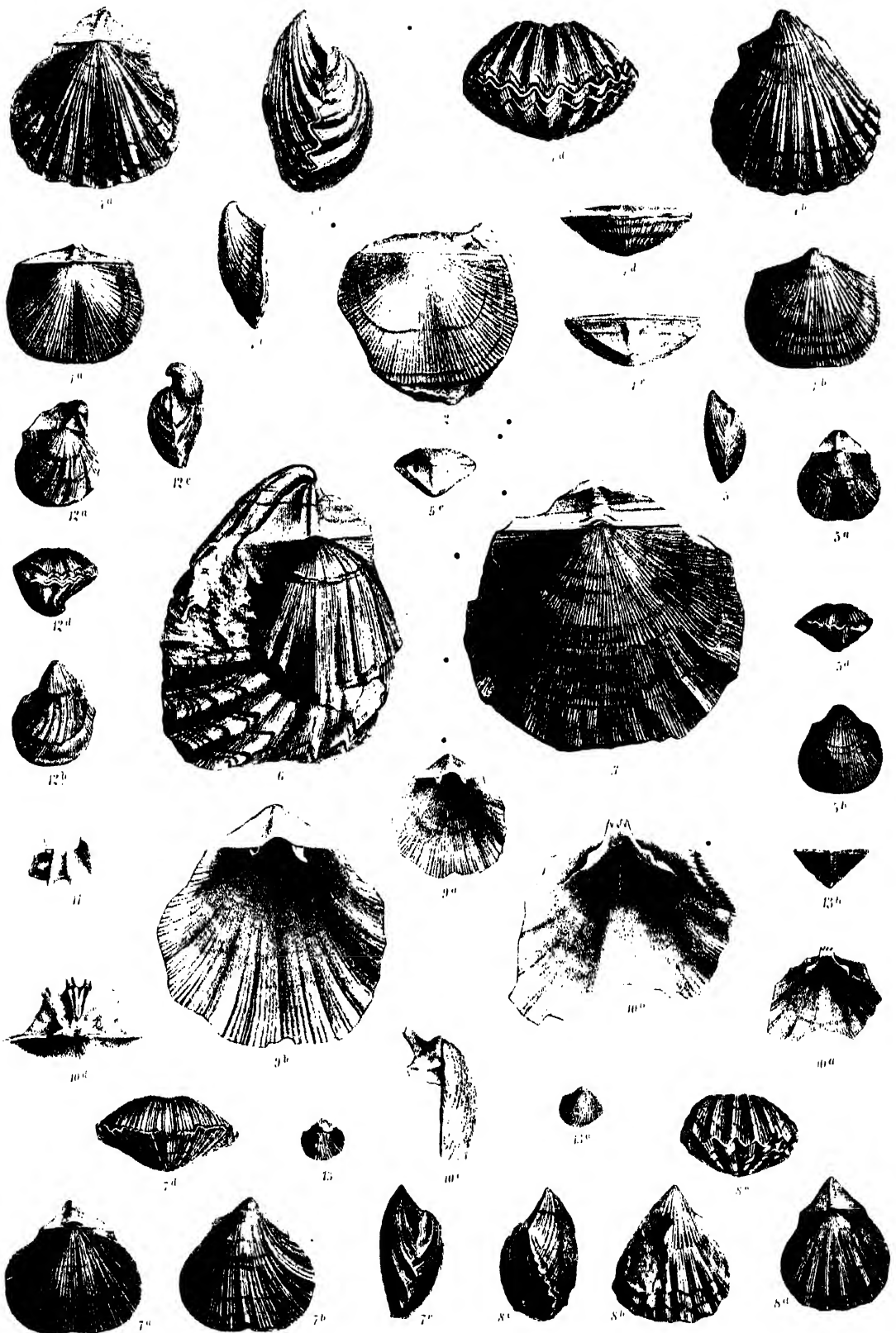




## P L A T E   L V.

### •   P R O D U C T U S - L I M E S T O N E .

- Figures      1, 2.   *ORTHOTHETES SEMIPLANUS*, Waagen, n. sp., p. 608.   Fig. 1, specimens from the Cephalopoda-bed of the upper Productus-limestone of Jabi; 1*a*, dorsal view; 1*b*, ventral view; 1*c*, lateral view; 1*d*, front view; 1*e*, view of the area.   Fig. 2, dorsal valve of a specimen from the same bed as the preceding, at Chidru.
3.   *DERBYIA PLICATELLA*, Waagen, n. gen. et sp., p. 601.   Specimen from the Cephalopoda-bed of the upper Productus-limestone of Jabi, dorsal view.
- 4—11.   *STREPTORHYNCHUS PECTINIFORMIS*, Davidson, p. 587.   Fig. 4, specimen from the Cephalopoda-bed of the upper Productus-limestone of Jabi.   Fig. 5, young specimen from the middle Productus-limestone of Vurcha.   Fig. 6, largest specimen known to me, from the upper Productus-limestone of Chidru.   Fig. 7, specimen from the Cephalopoda-bed of Jabi.   Fig. 8, specimen from the middle Productus-limestone of Swás.   Fig. 9, ventral valve of a specimen from the Cephalopoda-bed of Jabi; 9*a*, natural size; 9*b*, enlarged.   Fig. 10, dorsal valve of the same specimen as fig. 9; 10*a*, natural size; 10*b*, enlarged; 10*c*, lateral view; 10*d*, view from the hinge-line.   Fig. 11, internal view of the area of a specimen from Jabi.
- 12, 13.   *STREPTORHYNCHUS DISTORTUS*, Waagen, n. sp., p. 590.   Fig. 12, specimen from the top-bed of the upper Productus-limestone of Virgal.   Fig. 13, probably the young of this species from the same beds at Bilot.









# PLATE LVI.

## PRODUCTUS-LIMESTONE.

- Figure
1. *ORTHIS CORALLINA*, Waagen, n. sp., p. 572. Specimen from the coral-beds (middle Productus-limestone) of Virgal; *1a*, ventral view; *1b*, dorsal view; *1c*, lateral view; *1d*, front view (ventral valve above); *1e*, apical view (ventral valve above); all natural size.
  - 2, (& 5, 6). *ORTHIS DERBYI*, Waagen, n. sp., p. 565. Interior of a fragmentary ventral valve from the middle Productus-limestone of the Bazárwán.
  - 3, 4. *ORTHIS MARMOREA*, Waagen, n. sp., p. 566. Fig. 3, interior of a fragmentary ventral valve from the middle Productus-limestone of the Bazárwán. Fig. 4, dorsal valve of a specimen from the coral-beds, middle Productus-limestone, of Virgal; *4a*, dorsal view; *4b*, lateral view.
  - 5, 6 (& 2). *ORTHIS DERBYI*, Waagen, n. sp., p. 565. Fig. 5, specimen from the middle Productus-limestone of the Chittawán; *5a*, dorsal view; *5b*, ventral view; *5c*, lateral view (ventral valve to the left); *5d*, front view (ventral valve above). Fig. 6, specimens from the top beds of the upper Productus-limestone of Virgal; *6a*, dorsal view; *6b*, ventral view; *6c*, lateral view (ventral valve to the left); *6d*, front view (ventral valve above); all natural size.
  - 7, 8 (& 14—16). *ORTHIS INDICA*, Waagen, n. sp., p. 568. Two specimens from the middle Productus-limestone (lower region) of the mountains east of Katwáhi. Fig. 7, young specimen; *7a*, ventral view; *7b*, dorsal view; *7c*, lateral view; *7d*, front view; *7e*, dorsal view enlarged. Fig. 8, adult specimen; *8a*, ventral view; *8b*, dorsal view; *8c*, lateral view (ventral valve to the left); *8d*, front view (ventral valve below).
  9. *ORTHIS JANICEPS*, Waagen, n. sp., p. 570. Specimen from the middle Productus-limestone (lower region) of the mountains east of Katwáhi; *9a*, dorsal view; *9b*, ventral view; *9c*, lateral view (ventral valve to the right); *9d*, front view (ventral valve above); all natural size.
  - 10, 11, 12. *ORTHIS INCISIVA*, Waagen, n. sp., p. 574. Three specimens from the base of the middle Productus-limestone of Amb. Fig. 10, small specimen; *10a*, ventral view; *10b*, dorsal view; *10c*, lateral view (ventral valve to the left); *10d*, front view (ventral valve below); *10e*, dorsal view enlarged. Fig. 11, middle-sized specimen; *11a*, ventral view; *11b*, dorsal view; *11c*, lateral view (ventral valve to the right); *11d*, front view (ventral valve below). Fig. 12, largest specimen known to me, the ventral valve only.
  13. *ORTHIS PECOSII*, Marcou, p. 573. Specimen from the Chonetes-bed of the lower Productus-limestone of Amb; *13a*, ventral view; *13b*, dorsal view; *13c*, lateral view (ventral valve to the right); *13d*, front view (ventral valve below); *13e*, dorsal view, enlarged (the drawing is erroneous, the hinge-line being too long and too much projecting on both sides).
  - 14, 15, 16 (& 7—8). *ORTHIS INDICA*, Waagen, n. sp., p. 568. Three specimens from the lowest fossiliferous beds above the lavender-clay (lower Productus-limestone) of Amb. Fig. 14, young specimen (*14e*, dorsal view enlarged). Figs. 15 and 16, adult specimens.



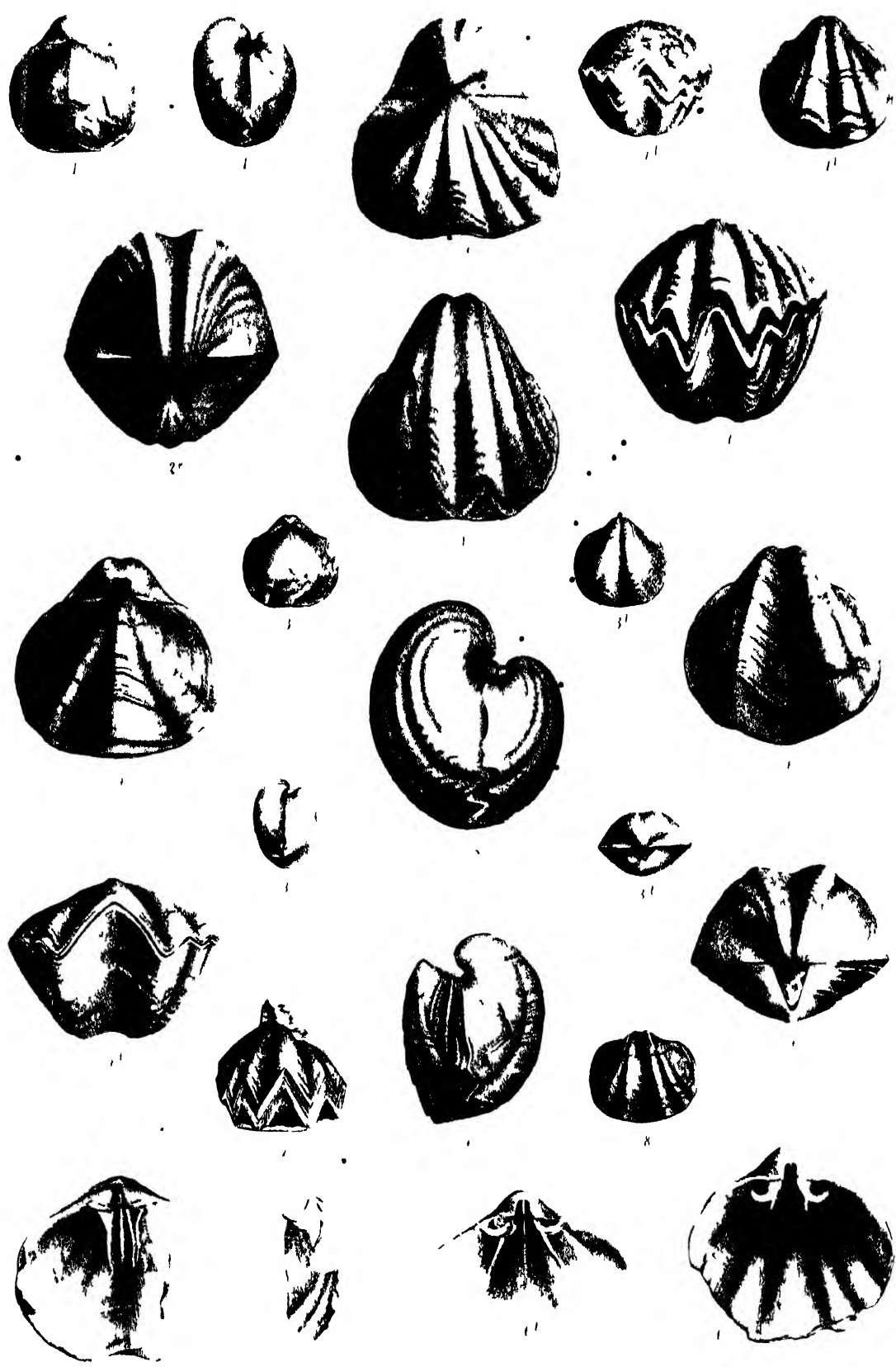




## PLATE LVII.

### PRODUCTUS-LIMESTONE.

- Figures 1 (& 3). *ENTELETES SUBLÆVIS*, Waagen, n. sp., p. 558. Full-grown specimen from the middle Productus-limestone of the Chittawán; 1*a*, ventral view; 1*b*, dorsal view; 1*c*, lateral view, ventral valve to the right; 1*d*, front view, ventral valve above.
2. *ENTELETES PENTAMEROIDES*, Waagen, n. sp., p. 561. Specimen, partly internal cast, from the middle Productus-limestone of Katwáhi; 2*a*, ventral view; 2*b*, dorsal view; 2*c*, lateral view, ventral valve to the right; 2*d*, front view, ventral valve above; 2*e*, cardinal view, ventral valve below.
- 3 (& 1). *ENTELETES SUBLÆVIS*, Waagen, n. sp., p. 558. Young specimen from Sheik Budin, probably coming from the middle Productus-limestone: 3*a*, ventral view; 3*b*, dorsal view; 3*c*, lateral view, ventral valve to the right; 3*d*, cardinal view, the ventral valve below.
- 4, 5, 6. *ENTELETES LATESINUATUS*, Waagen, n. sp., p. 559. Two specimens from the upper region of the middle Productus-limestone of Musakhcyl. Fig. 4, entire specimen; 4*a*, ventral view; 4*b*, dorsal view; 4*c*, lateral view, ventral valve to the left; 4*d*, front view, ventral valve above; 4*e*, cardinal view, ventral valve below. Fig. 5, ventral valve from the inside; 5*b*, lateral view, showing the median and one lateral septum. Fig. 6, interior of the dorsal valve of the same specimen as fig. 5; 6*b*, the same seen somewhat more from the front and slightly enlarged.
- 7—8. *ENTELETES FERRUGINEUS*, Waagen, n. sp., p. 556. Two specimens from the middle Productus-limestone of Omarkhycl. Fig. 7, ventral valve. Fig. 8, dorsal valve.







# MEMOIRS

OF

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### PALÆONTOLOGIA INDICA.

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